NASA SP-7091

International Exploration of Mars

A Special Bibliography
June 1991

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NASA SP-7091

International Exploration of Mars

A Special Bibliography
June 1991

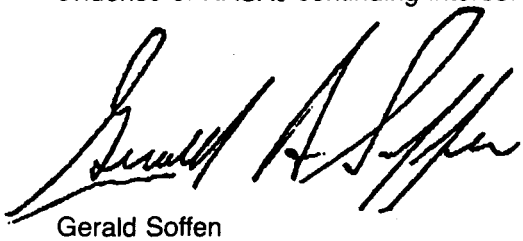
National Aeronautics and Space Administration
Office of Management
Scientific and Technical Information Program
Washington, DC 1991

This bibliography was compiled from the NASA STI Database and prepared by the NASA Center for AeroSpace Information.

INTRODUCTION

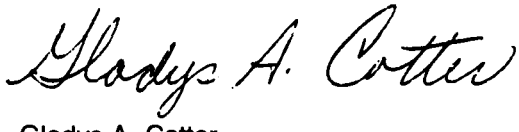
This bibliography contains references from the NASA Scientific and Technical Information Database, available on RECON, on the exploration of Mars. The citations include NASA reports as well as journal articles and conference proceedings. Historical references are cited for background.

The Scientific and Technical Information Program of NASA is pleased to contribute this comprehensive bibliography to the International Space University's 1991 session as evidence of NASA's continuing interest and support.



Gerald Soffen
Director, Office of University Programs
NASA Goddard Space Flight Center

Member, ISU Board of Directors



Gladys A. Cotter
Director
NASA Scientific and Technical Information Program

June 1991

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CHEMISTRY AND MATERIALS

ENGINEERING For related information see also *Physics.*

GEOSCIENCES For related information see also *Space Sciences.*

LIFE SCIENCES

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PHYSICS For related information see also *Engineering.*

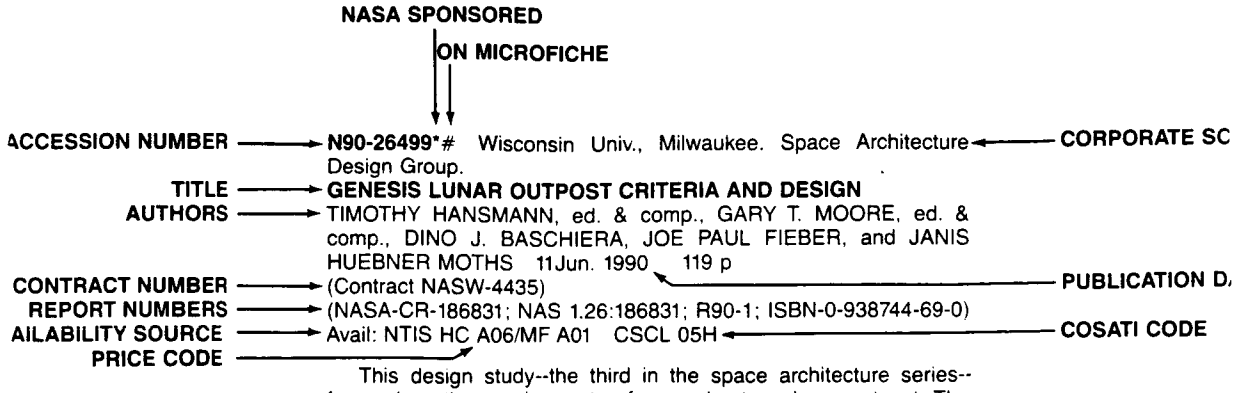
SOCIAL SCIENCES

SPACE SCIENCES For related information see also *Geosciences.*

GENERAL

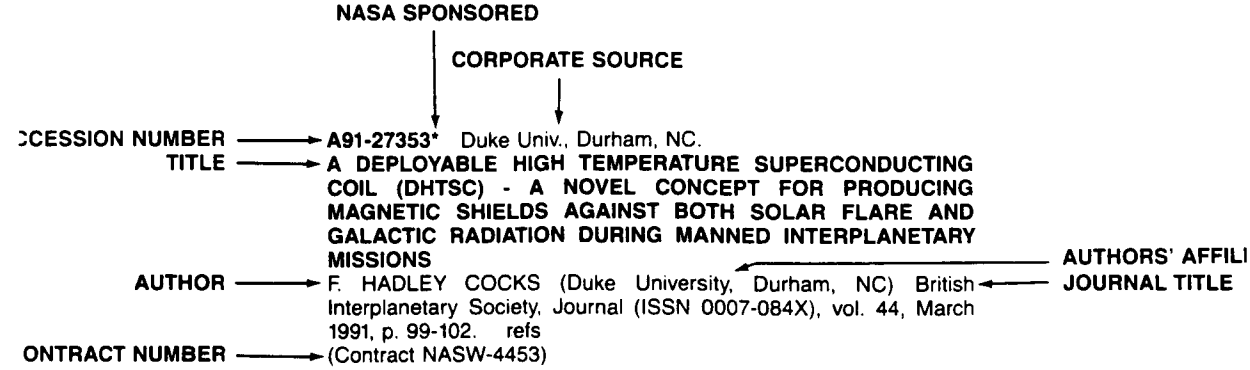
Includes aeronautical, astronautical, and space science related histories, biographies, and pertinent reports too broad for categorization; histories or broad overviews of NASA programs.

TYPICAL REPORT CITATION AND ABSTRACT



This design study--the third in the space architecture series--focused on the requirements of an early stage lunar outpost. The driving assumptions of the scenario was that the base would serve as a research facility and technology testbed for future Mars missions, a habitat supporting 12 persons for durations of up to 20 months, and would sustain the following five experimental facilities: Lunar surface mining and production analysis facility, construction technology and materials testbed, closed environmental life support system (CELSS) test facility, lunar farside observatory, and human factors and environment-behavior research facility. Based upon the criteria set forth in a previous programming document, three preliminary lunar base designs were developed. Each of the three schemes studied a different construction method and configuration. The designs were then evaluated in terms of environmental response, human habitability, transportability, constructability, construction dependability and resilience, and their suitability in carrying out the desired scientific research. The positive points of each scheme were then further developed by the entire project team, resulting in one integrated lunar outpost design. Author

TYPICAL JOURNAL ARTICLE CITATION AND ABSTRACT



The discovery of materials which are superconducting above 100 K makes possible the use of superconducting coils deployed beyond the hull of an interplanetary spacecraft to produce a magnetic shield capable of giving protection not only against solar flare radiation, but also even against Galactic radiation. Such deployed coils can be of very large size and can thus achieve the great magnetic moments required using only relatively low currents. Deployable high-temperature-superconducting coil magnetic shields appear to offer very substantial reductions in mass and energy compared to other concepts and could readily provide the radiation protection needed for a Mars mission or space colonies. Author

INTERNATIONAL EXPLORATION OF MARS

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ASTRONAUTICS (GENERAL)

A87-53091* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
MARTIAN SETTLEMENT
BARNEY B. ROBERTS (NASA, Johnson Space Center, Houston, TX) IN: The human quest in space; Proceedings of the Twenty-fourth Goddard Memorial Symposium, Greenbelt, MD, Mar. 20, 21, 1986. San Diego, CA, Univelt, Inc., 1987, p. 227-235; Discussion, p. 236, 237.
(AAS PAPER 86-117) Copyright
The rationale for a manned Mars mission and the establishment of a base is divided into three areas: science, resource utilization, and strategic issues. The effects of a Mars mission on the objectives of near-term NASA programs, and the applications of these programs to a Mars mission are examined. The use of extraterrestrial resources to supply space settlements and thereby reduce transportation costs is studied; the development of systems for extraterrestrial materials processing will need to be researched. The possibility of a joint U.S./Soviet Mars mission is discussed by the symposium participants. I.F.

A88-22044*# Martin Marietta Corp., Denver, CO.
HUMAN EXPLORATION OF MARS
BENTON C. CLARK (Martin Marietta Planetary Sciences Laboratory, Denver, CO) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 6 p. refs
(Contract NAS8-37126)
(AIAA PAPER 88-0064) Copyright
A systems study is underway of astronaut missions to Mars that could be accomplished over the next four decades. In addition to an emphasis on the transportation and facility infrastructure required for such missions, other relevant technologies and mission constraints are also being considered. These induce on-orbit assembly, trajectory type, launch opportunities, propellant storage, crew size, cabin pressure, artificial gravity, life-support systems, radiation hazards, power/energy storage, thermal control, human factors, communications, abort scenarios, landing techniques, exploration strategies, and science activities. A major objective of the study is to identify enabling and significantly enhancing technologies for accomplishing the goal of the human exploration of Mars. Author

A88-41289
TRANSPORTATION APPLICATIONS OF ELECTRIC PROPULSION
GRAEME ASTON (Electric Propulsion Laboratory, Inc., Tehachapi, CA) IN: Visions of tomorrow: A focus on national space transportation issues; Proceedings of the Twenty-fifth Goddard Memorial Symposium, Greenbelt, MD, Mar. 18-20, 1987. San Diego, CA, Univelt, Inc., 1987, p. 223-228, 231-245; Discussion, p. 228-230.
(AAS PAPER 87-128) Copyright
A comprehensive account is given of the nature and current development status of high specific impulse electric propulsion systems for spacecraft application in earth orbit, lunar settlement, planetary science, manned Mars mission, and interstellar travel. Electrostatic, electrothermal, and electromagnetic systems are possible; attention is presently given to electrostatic ion, electrothermal arcjet, and magnetoplasmadynamic thrusters. Lightweight solar and nuclear space power systems are key enabling technologies for electric propulsion; nuclear propulsion's use will be demonstrated by the Space Nuclear Power Source Reference Mission. O.C.

A88-52345* Spectra Research Systems, Inc., Huntsville, AL.
MANNED MARS MISSION PROGRAM CONCEPTS
E. C. HAMILTON, P. JOHNSON, J. PEARSON, and W. TUCKER (SRS Technologies, Huntsville, AL) IN: Space Congress, 25th, Cocoa Beach, FL, Apr. 26-29, 1988, Proceedings. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1988, p. 7-1 to 7-5. NASA-sponsored research.
Copyright
This paper describes the SRS Manned Mars Mission and Program Analysis study designed to support a manned expedition to Mars contemplated by NASA for the purposes of initiating human exploration and eventual habitation of this planet. The capabilities of the interactive software package being presently developed by the SRS for the mission/program analysis are described, and it is shown that the interactive package can be used to investigate the impact of various mission concepts on the sensitivity of mass required in LEO, schedules, relative costs, and risk. The results, to date, indicate the need for an earth-to-orbit transportation system much larger than the present STS, reliable long-life support systems, and either advanced propulsion or aerobraking technology. I.S.

A88-55451#
INTERNATIONAL MANNED MISSIONS TO MARS AND THE RESOURCES OF PHOBOS AND DEIMOS
BRIAN O'LEARY (Institute for Security and Cooperation in Outer Space, Phoenix, AZ) IAF, International Astronautical Congress, 39th, Bangalore, India, Oct. 8-15, 1988. 14 p. refs
(IAF PAPER 88-591) Copyright
The potential for a joint manned mission to the moons of Mars with a possible sortie to the Martian surface is examined. The advantages of landing on the Martian moons include accessibility, location, the potential for in-situ processing, and the minimization of mission propulsion requirements. The dangers of dust storms on the Martian surface are obviated, and the application of the Space Shuttle external tank (ET) to such a mission is addressed. The use of the ET for volatile processing at the moons of Mars is discussed. A four-mission program toward developing the bases on the Martian moons is discussed, taking the requirements and economics into account. C.D.

A89-19391
US AND SOVIET PLANETARY EXPLORATION - THE NEXT STEP IS MARS, TOGETHER
BURTON I. EDELSON and JOHN L. MCLUCAS Space Policy (ISSN 0265-9646), vol. 4, Nov. 1988, p. 337-349.
Copyright
The history of U.S. and Soviet lunar and planetary exploration efforts is recalled, and arguments in favor of a joint program to

explore Mars are presented. The competitive nature of the previous and current space programs is discussed; the technological fields in which the U.S. or USSR has an advantage are indicated; and the need to follow up on the 1986 Soviet proposal of a joint mission is stressed. The first steps recommended to the U.S. administration are (1) establishing a bilateral or international Mars program concept, (2) setting robotic exploration in the late 1990s and manned exploration in the next century as goals, and (3) convening an international group of engineers and scientists to make detailed plans. T.K.

A89-37799* Stanford Univ., CA.
USE OF MARTIAN RESOURCES IN A CONTROLLED ECOLOGICAL LIFE SUPPORT SYSTEM (CELSS)
DAVID T. SMERNOFF (Stanford University, CA) and ROBERT D. MACELROY (NASA, Ames Research Center, Moffett Field, CA) British Interplanetary Society, Journal (ISSN 0007-084X), vol. 42, April 1989, p. 179-184. refs
Copyright

Possibile crew life support systems for Mars are reviewed, focusing on ways to use Martian resources as life support materials. A system for bioregenerative life support using photosynthetic organisms, known as the Controlled Ecological Life Support System (CELSS), is examined. The possible use of higher plants or algae to produce oxygen on Mars is investigated. The specific requirements for a CELSS on Mars are considered. The exploitation of water, respiratory gases, and mineral nutrients on Mars is discussed. R.B.

A89-43365* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
A MANNED MARS ARTIFICIAL GRAVITY VEHICLE
DAVID N. SCHULTZ, CHARLES C. RUPP, GREGORY A. HAJOS, and JOHN M. BUTLER, JR. (NASA, Marshall Space Flight Center, Huntsville, AL) *IN: Space tethers for science in the space station era; Proceedings of the Second International Conference, Venice, Italy, Oct. 4-8, 1987.* Bologna, Societa Italiana di Fisica, 1988, p. 320-335.
Copyright

Data are presented on an artificial-gravity vehicle that is being designed for a manned Mars mission, using a 'split-mission' concept, in which an unmanned cargo vehicle is sent earlier and stored in a Mars orbit for a rendezvous with a manned vehicle about 1.5 years later. Special attention is given to the vehicle trajectory and configuration, the tether design, and the vehicle weight and launch requirements. It is shown that an artificial-G vehicle for a manned Mars missions is feasible technically and programmatically. Using an artificial-G vehicle instead of a zero-G vehicle for the piloted portion of a split mission provides physiological and human-factor-related benefits, does not eliminate requirements for zero-G countermeasures research (since zero-G is an abort mode), and could possibly reduce some life science activities. Diagrams are included. I.S.

A89-45833
POTENTIAL APPLICATION OF SPACE STATION TECHNOLOGY IN LUNAR BASES AND MANNED MARS MISSIONS
J. M. GARVEY and M. M. MANKAMYER (McDonnell Douglas Astronautics Co., Space Station Div., Huntington Beach, CA) *IN: Engineering, construction, and operations in space; Proceedings of the Space '88 Conference, Albuquerque, NM, Aug. 29-31, 1988.* New York, American Society of Civil Engineers, 1988, p. 1308-1319. *refs*
Copyright

To meet the goals of its Space Station program, NASA is developing a large set of improved space systems capabilities. In areas such as power generation and distribution, on-board data management, and life support, Station technology will represent a major advance over current systems. Given the substantial investment required to create these capabilities, it is worthwhile to consider other potential uses for them. This paper constitutes an early attempt to assess such follow-on applications, particularly in manned space exploration initiatives such as a lunar base and/or manned Mars expedition. Author

A89-47067#
MANNED MARS MISSION OVERVIEW
BRUCE M. CORDELL (General Dynamics Corp., Space Systems Div., San Diego, CA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 25th, Monterey, CA, July 10-13, 1989. 32 p. refs
(AIAA PAPER 89-2766) Copyright

The mission strategies and concepts, technologies and systems, and program stragegies and implications associated with manned Mars missions and with establishment of bases on Mars are discussed. The results of an overview of the existing information and technologies indicate that the human exploration of Mars and the establishment of settlements is technologically feasible. It is suggested that an initial manned base on Phobos may be the most efficient and inexpensive way to begin the human exploration of Mars. The propulsion issues and the mission concepts are discussed with special consideration given to nuclear systems and extraterrestrial propellant production, as well as to space infrastructures, systems, and operations necessary for the support of manned Mars missions. Attention is also given to political and social issues that will influence the decision and the starting time of the human exploration of Mars. I.S.

A89-54248
TO MARS AND BEYOND
BEN BOVA Air and Space (ISSN 0886-2257), vol. 4, Oct.-Nov. 1989, p. 42-48.
Copyright

The development of propulsion systems with the ability to allow for human exploration of Mars and further into the solar systems is discussed. Various types of rocket engines, such as chemical, nuclear, and electrical, are examined in terms of fuel efficiency and specific impulse. Consideration is also given to laser propulsion, a solar sail, and fusion. I.F.

A90-13570*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
AN INTERNATIONAL MARS EXPLORATION PROGRAM
DONALD G. REA, GLENN E. CUNNINGHAM (JPL, Pasadena, CA), MARK K. CRAIG (NASA, Johnson Space Center, Houston, TX), and HAROLD L. CONWAY (NASA, Washington, DC) IAF, International Astronautical Congress, 40th, Malaga, Spain, Oct. 7-13, 1989. 7 p.
(IAF PAPER 89-493) Copyright

The scientific reasons for a Mars exploration program are reviewed, and the robotic phase of such a program is examined. The functions and requirements of the rovers, surface stations and penetrators are addressed, as are those of the imaging and communications orbiters. The navigational functions which support the aerocapture and landing vehicles are examined. C.D.

A90-16528
MARS IS OURS - STRATEGIES FOR A MANNED MISSION TO MARS
TIINA O'NEIL, DANIEL THURS, MICHAEL NARLOCK, and SHAWN LAATSCH *IN: The case for Mars III: Strategies for exploration - Technical.* San Diego, CA, Univelt, Inc., 1989, p. 13-28. refs
(AAS PAPER 87-228) Copyright

The societal, engineering, and scientific aspects of a manned mission to Mars are investigated, as part of a NASA/University of Wisconsin sponsored high school student contest. The societal concerns cover the economic perspective of a multinational venture providing more resources, ideas, and personnel than a unilateral effort. Engineering issues consist of ship design, propulsion, and support systems; propelled by liquid rockets, the Mars Transit Vehicle (MTV) is conceived as a modular craft composed of several pods; the space crew would inhabit the first two pods. The scientific aspect concerns the major questions, means, and requirements

to be answered for a manned Mars mission, with objectives that would include the determination of location and potability of Martian water deposits. C.E.

A90-16548
MARS MISSION AND PROGRAM ANALYSIS
EDWARD E. MONTGOMERY and JAMES C. PEARSON, JR. (Spectra Research Systems, Inc., Huntsville, AL) IN: The case for Mars III: Strategies for exploration - Technical. San Diego, CA, Univelt, Inc., 1989, p. 293-309. refs
(AAS PAPER 87-249) Copyright

The total initial mass required in the Space station orbit is estimated for several different operational scenarios culminating in the retrieval of Mars Space Vehicle stages to the space station for refurbishment and reuse. Interplanetary and planetary velocity change requirements are calculated for a 2003 high thrust conjuction class direct stopover mission to Mars and subsequently employed in mass fraction equations to estimate mass of the Mars vehicle and OTVs. The implications on ETO vehicle payload capacity and launch rate are also presented parametrically. Evaluations include the effects of aerobraking, propellant boiloff, and recovery trajectory. Author

A90-16560
MANNED MARS MISSIONS AND EXTRATERRESTRIAL RESOURCE ENGINEERING TEST AND EVALUATION
STEWART W. JOHNSON (BDM Corp., Albuquerque, NM) and RAYMOND S. LEONARD (Ad Astra, Ltd., Santa Fe, NM) IN: The case for Mars III: Strategies for exploration - Technical. San Diego, CA, Univelt, Inc., 1989, p. 455-468. Research supported by BDM Corp. and Ad Astra, Ltd. refs
(AAS PAPER 87-261) Copyright

This paper emphasizes the importance of early involvement of the test and evaluation perspective and approach in the engineering analysis, design, and development of capabilities for a manned Mars mission that incorporates extraterrestrial resource extraction and use. The effectiveness and suitability of mission equipment and proposed resource extraction processes must be shown by test and evaluation involving analysis, simulation, ground test, and flight test. Facilities and resources for test and evaluation must be acquired in a timely fashion, and time allowed for test and evaluation. Author

A90-16651* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
THE CASE FOR MARS III: STRATEGIES FOR EXPLORATION - GENERAL INTEREST AND OVERVIEW
CAROL R. STOKER, ED. (NASA, Ames Research Center, Moffett Field, CA) San Diego, CA, Univelt, Inc. (Science and Technology Series. Volume 74), 1989, 743 p. For individual items see A90-16652 to A90-16690.
Copyright

Papers on the possibilities for manned Mars missions are presented, covering topics such as space policy, space education and Mars exploration, economic issues, international cooperation, life support, biomedical factors, human factors, the Mars Rover Sample Return Mission, and possible unmanned precursor missions to Mars. Other topics include the scientific objectives for human exploration of Mars, mission strategies, possible transportation systems for manned Mars flight, advanced propulsion techniques, and the utilization of Mars resources. Additional subjects include the construction and maintenance of a Martian base, possible systems for mobility on the Martian surface, space power systems, and the use of the Space Station for a Mars mission. R.B.

A90-16652* National Aeronautics and Space Administration, Washington, DC.
A STRATEGY FOR MARS: THE CASE FOR MARS III - KEYNOTE ADDRESS
JAMES C. FLETCHER (NASA, Washington, DC) IN: The case for Mars III: Strategies for exploration - General interest and overview. San Diego, CA, Univelt, Inc., 1989, p. 3-11.
(AAS PAPER 87-175) Copyright

Plans for defining a Mars mission and developing the technologies needed for a Mars mission are discussed. The information about Mars obtained from the Viking mission is reviewed. The establishment of a lunar base and the role of such a base in a manned mission to Mars are examined. The problems of a long-term mission in microgravity, the possible development of artificial gravity, the Mars Sample Return mission, and various scenarios for a manned mission to Mars are considered. R.B.

A90-16653
DECISIONS ON SPACE INITIATIVES
RADFORD BYERLY, JR. (Colorado, University, Boulder) IN: The case for Mars III: Strategies for exploration - General interest and overview. San Diego, CA, Univelt, Inc., 1989, p. 19-25. refs
(AAS PAPER 87-177) Copyright

Issues related to the process of making decisions on major space initiatives are discussed. The decision-making processes for the Apollo, Space Shuttle, and Space Station programs are reviewed. Consideration is given to current political support for the Space Station and the question of whether the moon or Mars should be the next goal of the space program. R.B.

A90-16664* National Aeronautics and Space Administration, Washington, DC.
PLANETARY PROTECTION AND BACK CONTAMINATION CONTROL FOR A MARS ROVER SAMPLE RETURN MISSION
JOHN D. RUMMEL (NASA, Life Sciences Div., Washington, DC) IN: The case for Mars III: Strategies for exploration - General interest and overview. San Diego, CA, Univelt, Inc., 1989, p. 259-263.
(AAS PAPER 87-197) Copyright

A commitment to avoid the harmful contamination of outer space and avoid adverse changes in the environment of the earth has been long reflected in NASA's Planetary Protection policy. Working under guidelines developed by the Committee on Space Research (COSPAR), NASA has implemented the policy in an interactive process that has included the recommendations of the U.S. National Academy of Sciences. Measures taken to prevent the contamination of earth during the Apollo missions were perhaps the most visible manifestations of this policy, and provided numerous lessons for future sample return opportunities. This paper presents the current status of planetary protection policy within NASA, and a prospectus on how planetary protection issues might be addressed in relation to a Mars Rover Sample Return mission. Author

A90-16667* National Aeronautics and Space Administration, Washington, DC.
LIFE SCIENCES INTERESTS IN MARS MISSIONS
JOHN D. RUMMEL and LYNN D. GRIFFITHS (NASA, Life Sciences Div., Washington, DC) IN: The case for Mars III: Strategies for exploration - General interest and overview. San Diego, CA, Univelt, Inc., 1989, p. 287-294.
(AAS PAPER 87-200) Copyright

NASA's Space Life Sciences research permeates plans for Mars missions and the rationale for the exploration of the planet. The Space Life Sciences program has three major roles in Mars mission studies: providing enabling technology for piloted missions, conducting scientific exploration related to the origin and evolution of life, and protecting space crews from the adverse physiological effects of space flight. This paper presents a rationale for exploration and some of the issues, tradeoffs, and visions being addressed in the Space Life Sciences program in preparation for Mars missions. Author

A90-16668* Martin Marietta Corp., Denver, CO.
MANNED MARS SYSTEMS STUDY
BENTON C. CLARK (Martin Marietta Planetary Sciences Laboratory, Denver, CO) IN: The case for Mars III: Strategies for exploration - General interest and overview. San Diego, CA, Univelt, Inc., 1989, p. 297-307.
(Contract NAS8-37126)
(AAS PAPER 87-201) Copyright

A study is underway to determine attractive system options, perform trade studies, and provide comparative data for astronaut missions to Mars. Because of an emphasis in this work on deriving requirements and candidates for the transportation and facility infrastructure for such missions, all relevant technologies and mission constraints are also being considered. These include on-orbit assembly, trajectory type, launch opportunities, propellant storage, crew size, cabin pressure, artificial gravity, life-support systems, radiation hazards, power/energy storage, thermal control, human factors, communications, abort scenarios, landing techniques, exploration strategies and science activities. It is planned to scope several example missions and to identify enabling and significantly enhancing technologies for accomplishing the goals of the human exploration of Mars. Author

A90-16669
PILOTED SPRINT MISSIONS TO MARS
JOHN C. NIEHOFF and STEPHEN J. HOFFMAN (Science Applications International Corp., Schaumburg, IL) IN: The case for Mars III: Strategies for exploration - General interest and overview. San Diego, CA, Univelt, Inc., 1989, p. 309-324.
(AAS PAPER 87-202) Copyright

This paper describes a piloted mission to Mars early in the 21st century, using near-term technology; results from a mission study are presented. A trajectory option is identified that allows piloted round-trip missions to be completed within approximately one year. These flights are called sprint missions. Study results show that two vehicles would be required to complete the mission. The first is an automated cargo vehicle, which has an initial mass of 600 metric tons (including injection stage) in LEO. The second vehicle is the piloted spacecraft, which has an initial mass (including injection stages) of 750 metric tons LEO. Aerobraking is used by both the cargo and piloted vehicles at Mars and by the piloted vehicle upon earth return. Key milestones in support of the proposed mission scenario are identified. Author

A90-16670
MARS 1999 - A CONCEPT FOR LOW COST NEAR-TERM HUMAN EXPLORATION AND PROPELLANT PROCESSING ON PHOBOS AND DEIMOS
BRIAN O'LEARY (Future Focus, Scottsdale, AZ) IN: The case for Mars III: Strategies for exploration - General interest and overview. San Diego, CA, Univelt, Inc., 1989, p. 353-372. refs
(AAS PAPER 87-204) Copyright

This study shows that a mission to the moons of Mars with a sortie option to the Martian surface during 1998-99 is technically feasible provided a political decision is made by 1990. A number of reasons favor the 1999 opportunity, including small delta-V values, low probability of planet-obscuring dust storms, and near-zero solar flare activity. The space shuttle external tank can be adapted as a cryogenic propellant and cargo launcher to low earth orbit (LEO), as a Mars mission module transfer vehicle, and as a cryogenic storage facility on-orbit and at Phobos/Deimos (PhD). A synergistic four mission program is proposed wherein 10,000 metric tons of water extracted from PhD could be delivered to LEO and the surfaces of Mars and the moon by 2005. As a result, Mars and lunar bases could be established, and a space industrial infrastructure could grow more rapidly than in other space development scenarios. The scientific, political and economic incentives for PhD warrant increased attention in manned Mars mission, program, and system studies. Author

A90-16671* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
EARTH ORBITAL PREPARATION FOR MARS EXPEDITIONS
ROBERT L. STAEHLE (JPL, Pasadena; World Space Foundation, South Pasadena, CA) IN: The case for Mars III: Strategies for exploration - General interest and overview. San Diego, CA, Univelt, Inc., 1989, p. 373-396. refs
(AAS PAPER 87-205) Copyright

Consideration is given to the facilities in earth orbit that would be required to prepare for a manned mission to Mars. It is suggested that the facilities required for the development of technology for a Mars mission include the Space Station, a variable gravity research station, and an assembly dock, in addition to ground facilities. The types of research that would be conducted at each of these facilities are examined. R.B.

A90-16672* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
TECHNOLOGY FOR MANNED MARS FLIGHT
BARNEY B. ROBERTS (NASA, Johnson Space Center, Houston, TX) IN: The case for Mars III: Strategies for exploration - General interest and overview. San Diego, CA, Univelt, Inc., 1989, p. 399-411. refs
(AAS PAPER 87-206) Copyright

It is important for NASA to begin development of the technologies and strategies necessary to support a Mars mission. Most of the technologies required are long lead time items and must be started now to preserve the option for Mars landings at the turn of the century. It is a common assumption that a piloted mission to Mars could be accomplished with current technology. Although this is probably true to some degree, the mass in low earth orbit would be so large that the mission would be impractical and maybe impossible. Technologies for advanced propulsion, advanced life support systems, aerobraking, and utilization of in situ resources can greatly enhance the ability to execute this class of mission. Author

A90-16686* Utah State Univ., Logan.
BALLOON-BORNE CHARACTERIZATION OF THE MARTIAN SURFACE AND LOWER ATMOSPHERE
F. J. REDD (Utah State University, Logan), R. J. LEVESQUE, and G. E. WILLIAMS IN: The case for Mars III: Strategies for exploration - General interest and overview. San Diego, CA, Univelt, Inc., 1989, p. 633-645. Research supported by NASA. refs
(AAS PAPER 87-221) Copyright

A recent NASA-sponsored design course at Utah State University (USU) has focused upon a Mars Lander/Rover system designed to descend from a Martian orbit and deploy both surface and balloon-borne instruments to examine the Martian surface and lower atmosphere. The latter stages of the USU design effort placed major emphasis on the design of the balloon rover. This paper presents the results of that emphasis by discussing the payload requirements, identification of the design parameters, surface vs. descent deployment, design tradeoff studies, site-influenced departures from the baseline design, the final design concept, and the resulting balloon performance. A single hydrogen superpressure balloon is selected for use in the design mission. The paper concludes that characterization of the Martian surface and lower atmosphere by a descent-deployed, balloon-borne rover is a viable concept that should be actively pursued. Author

A90-17806
EMERGING VIEWS ON A JOINT SOVIET-U.S. MARS MISSION
VADIM VLASOV (Moskovskii Aviatsionnyi Institut, Moscow, USSR) and MICHAEL POTTER (Egan Group; Georgetown University, Washington, DC) Space Policy (ISSN 0265-9646), vol. 5, Nov. 1989, p. 269-272.
Copyright

Political and space policy developments in the U.S. and in the USSR are evaluated, focusing on the way in which these developments might influence the possibility of a joint U.S./USSR mission to Mars. Consideration is given to economic issues and political support for space programs in the two countries. A strategy for working towards a joint Mars mission is proposed. R.B.

A91-10052#
PLANNING FOR HUMAN VOYAGES TO MARS
ERNST STUHLINGER AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 7 p.
(AIAA PAPER 90-3615) Copyright

Proposals for manned voyages to Mars were made repeatedly during the past hundred years, based on chemical, electric, and nuclear rocket systems. Some of the more recent studies offered detailed design and engineering data for Mars missions. President

Bush's Space Exploration Initiative in 1989 resulted in extended compilations of data concerning the Martian surface and environment; steps toward the establishment of a master plan for a manned Mars mission should now be taken. A concept for a Mars mission with a nuclear-electric propulsion system is proposed in the present paper. Author

A91-10143*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MARS EXPLORATION MISSIONS
GLENN E. CUNNINGHAM (JPL, Pasadena, CA) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 7 p. refs
(AIAA PAPER 90-3779) Copyright

Several robotic exploration missions to Mars that are proposed for inclusion in the Space Exploration Mission are reviewed. The missions discussed range from remote sensing orbital missions to landed missions, such as simple surface stations and roving vehicles. The discussion covers engineering and science objectives of the missions, data acquisition strategy, mission sequence, types of missions, and a brief description of each of the missions. V.L.

A91-10157*# National Aeronautics and Space Administration, Washington, DC.
TECHNOLOGY AND MARS EXPLORATION
JOHN C. MANKINS (NASA, Washington, DC) and CORINNE M. BUONI (Science Applications International Corp., Washington, DC) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 10 p.
(AIAA PAPER 90-3797) Copyright

The currently envisioned technology needs of the Space Exploration Initiative are surveyed. Earth-to-orbit transportation technology requirements are summarized. Space transportation needs regarding aerobraking, space-based engines, autonomous landing, autonomous rendezvous and docking, vehicle structures and cryogenic tankage, artificial gravity, nuclear propulsion, nuclear thermal propulsion, and nuclear electric propulsion. For in-space operations, cryogenic fluid systems, in-space assembly and construction, and vehicle processing and servicing are addressed. For surface operations on the moon and Mars, space nuclear power, resource utilization, planetary rovers, surface solar power, and surface habitats and construction are discussed. Regenerative life support, radiation protection, extravehicle activity, are considered along with factors pertaining to scientific activity in space and information systems and communications. C.D.

A91-10193*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
OVERVIEW OF THE SURFACE ARCHITECTURE AND ELEMENTS COMMON TO A WIDE RANGE OF LUNAR AND MARS MISSIONS
JOHN F. CONNOLLY (NASA, Johnson Space Center, Houston, TX) and LARRY D. TOUPS (Lockheed Engineering and Sciences Co., Houston, TX) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 10 p.
(AIAA PAPER 90-3847) Copyright

NASA has studied future missions to the moon and Mars since the 1960's, and most recently during the studies for the Space Exploration Initiative chartered by President Bush. With these most recent studies, the Lunar and Mars Exploration Program Office is looking at a number of possible options for the human exploration of the solar system. Objectives of these options include science and exploration, testing and learning centers, local planetary resource development, and self sufficient bases. To meet the objectives of any particular mission, efforts have focused primarily in three areas: (1) space transportation vehicles, (2) the associated space infrastructure to support these vehicles, and (3) the necessary infrastructure on the planet surface to carry out the mission objectives. This paper looks at work done by the Planet Surface Systems Office at JSC in the third area, and presents an overview of the approach to determining appropriate equipment and elements of the surface infrastructure needed for these mission alternatives. It describes the process of deriving appropriate surface architectures with consideration of mission objectives leading to system concepts, designation of elements and element placement. Author

A91-10220#
TRANSPORTATION APPROACHES FOR MANNED MARS MISSIONS
BRUCE M. CORDELL (General Dynamics Corp., Space Systems Div., San Diego, CA) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 10 p. refs
(AIAA PAPER 90-3892) Copyright

This paper describes the Space Exploration Initiative (SEI) objectives, as well as some strategies and scenarios which emphasize program viability, crew safety, efficient transportation systems, the use of space resources, and the human settlement of Mars. The space propulsion options which can be easily accommodated into the SEI program and a SEI strategy featuring the search for water on Mars are described. Special attention is given to an example (Exofuel) of possible commercial strategy involving the Martian moons. In one of several possible Exofuel scenarios, a water extractor and an in situ propellant production plant on Deimos produce propellants that are retrieved to a high elliptical earth orbit, from which they are transferred via a space tanker vehicle to LEO where they are used to fuel lunar or planetary spacecraft. A summary is presented of the performance and cost data generated during the initial analysis of the potential of the Martian moons for commercial development. I.S.

A91-13752*# National Aeronautics and Space Administration, Washington, DC.
TECHNOLOGY NEEDS OF THE EXPLORATION INITIATIVE
ARNOLD ALDRICH, ROBERT ROSEN, MARK CRAIG, and JOHN C. MANKINS (NASA, Office of Aeronautics, Exploration and Technology, Washington, DC) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 11 p. refs
(IAF PAPER 90-032) Copyright

An overview of the U.S. Space Exploration Initiative (SEI) is presented. The two primary objectives of the initiative are a return to the moon to create a permanent lunar base and a human mission to Mars. Even though mission architectural concepts are not yet defined, previous studies indicate that the SEI will require developments in numerous areas, including advanced engines for space transportation, in-space assembly and construction to support permanent basing of exploration systems in space, and advanced surface operations capabilities including satisfactory levels of power and surface roving vehicles, and technologies to safely support human space operations of long duration. The process of mission definition has begun and it is shown that it is possible to identify a family of fundamental functional building blocks from which all SEI mission architectures will be constructed. R.E.P.

A91-13867#
CONCEPTS FOR SHORT DURATION MANNED MARS ROUND TRIP
C. L. DAILEY and J. L. HIEATT (TRW Space and Technology Group, Redondo Beach, CA) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 5 p.
(IAF PAPER 90-198) Copyright

For the first missions to Mars a stay time of 30 to 60 days is desired. Nuclear electric propulsion offers this capability at a significant reduction in total mass required in low earth orbit compared to either thermal nuclear or chemical propulsion concepts. Further, nuclear electric propulsion vehicles can be designed for maintenance and reuse. This paper summarizes the comparison of a single vehicle mission to Mars with the use of two vehicles, a manned transport and a freighter. The results indicate that the use of two vehicles provides a significant advantage in terms of weight to low earth orbit, and that there is

a distinct possibility of designing an efficient single vehicle which can be used to carry either man or cargo. Author

A91-14015#
THE MOON/MARS ADVENTURE - WHICH ROLE AND WHICH IMPACTS FOR EUROPE?
FRANCIS THEILLIER and PATRICK EYMAR (Aerospatiale, Division Systemes Strategiques et Spatiaux, Les Mureaux, France) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 10 p.
(IAF PAPER 90-411) Copyright

The major results of a study performed by Aerospatiale on the potential role for Europe in an interplanetary manned mission are summarized. The scientific, utilitarian, political, and humanitarian objectives of such a mission are discussed, emphasizing the importance of those activities which would lead to better knowledge of the solar system, would scientifically or industrially utilize the advantage of vacuum, lack of electromagnetic noise, and planet resources, and benefit outpost and space transportation node aspects. The dates, deadlines, and duration considered for such missions, their degree of automation, and the degree of autonomy provided surface bases are all discussed. A number of scenarios concerning Europe's role in a space program are considered. A scenario is examined in which Europe would postpone for an indefinite period the exploration and colonization of the moon and Mars should cooperative agreements fail to be reached. L.K.S.

A91-14019*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ROBOTIC MISSIONS TO MARS - PAVING THE WAY FOR HUMANS
D. S. PIVIROTTO, R. D. BOURKE, G. E. CUNNINGHAM, M. P. GOLOMBEK, F. M. STURMS (JPL, Pasadena, CA), R. C. KAHL, N. LANCE (NASA, Johnson Space Center, Houston, TX), and J. S. MARTIN (NASA, Washington, DC) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 8 p.
(IAF PAPER 90-416) Copyright

NASA is in the planning stages of a program leading to the human exploration of Mars. A critical element in that program is a set of robotic missions that will acquire information on the Martian environment and test critical functions (such as aerobraking) at the planet. This paper presents some history of Mars missions, as well as results of recent studies of the Mars robotic missions that are under consideration as part of the exploration program. These missions include: (1) global synoptic geochemical and climatological characterization from orbit (Mars Observer), (2) global network of small meteorological and seismic stations, (3) sample returns, (4) reconnaissance orbiters and (5) rovers. Author

A91-14037#
ANALYSIS OF ALTERNATIVE INFRASTRUCTURES FOR LUNAR AND MARS EXPLORATION
MICHAEL C. SIMON and PAUL H. BIALLA (General Dynamics Corp., Space Systems Div., San Diego, CA) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 11 p. refs
(IAF PAPER 90-442) Copyright

This paper reports on an ongoing study to examine alternative infrastructures for lunar and Mars exploration. This study was initiated immediately after the July 20, 1989 announcement by President Bush that the U.S. would undertake manned missions to the moon and Mars. The first step was to identify four alternative options: (1) lowest cost, (2) least risk, (3) greatest science and technology benefits, and (4) maximum human presence in space. For each option, lunar and Mars surface elements and space transportation elements were identified which were consistent with the option's underlying philosophy. These four cases were then compared on the basis of such data as transportation element flights rates, element mass and cost estimates, program schedules, and funding profiles. Finally, a recommended strategy was synthesized, based on the attributes found to be most desirable within these four options. Features of this recommended scenario include early missions to the moon and Mars, achievement of frequent milestones to sustain public interest, and provisions for international cooperation in meeting objectives. Author

A91-14132#
MARS DIRECT - HUMANS TO THE RED PLANET BY 1999
ROBERT M. ZUBRIN and DAVID A. BAKER (Martin Marietta Astronautics Group, Denver, CO) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 17 p. refs
(IAF PAPER 90-672) Copyright

Both the initial and evolutionary phases of the Mars Direct plan, including mission architecture, vehicle designs, and exploratory strategy leading to the establishment of a 48-person permanent Mars base are discussed. Mars Direct is an approach to the Space Exploration Initiative which would initiate a program of manned Mars exploration as early as 1999. The initial phase would utilize only chemical propulsion, sending four persons on conjunction class Mars exploratory missions. Two heavy lift boosters launches are required to support each mission, with the first launch delivering an unfueled earth return vehicle to the Martian surface, where it would fill itself with methane/oxygen bipropellant manufactured primarily out of indigenous resources. A second launch would deliver the crew to the prepared site after propellant production is completed. The crew would then conduct a 1.5-year regional exploration and return directly to earth in the prepared vehicle. L.K.S.

A91-21463*# Martin Marietta Corp., Denver, CO.
MARS DIRECT - A SIMPLE, ROBUST, AND COST EFFECTIVE ARCHITECTURE FOR THE SPACE EXPLORATION INITIATIVE
ROBERT M. ZUBRIN, DAVID A. BAKER (Martin Marietta Corp., Astronautics Group, Denver, CO), and OWEN GWYNNE (NASA, Ames Research Center, Moffett Field, CA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 28 p. refs
(AIAA PAPER 91-0329) Copyright

Both the Martian and lunar forms of implementation of the Mars Direct architecture are discussed. Candidate vehicle designs are presented and the means of performing the required in situ propellant production is explained. The in situ propellant process is also shown to present very high leverage for a Mars Rover Sample Return mission flown as a scaled down precursor version of the manned Mars Direct. Methods of coping with the radiation and zero gravity problems presented by a manned Mars mission are discussed. Prime objectives for surface exploration are outlined and the need for substantial surface mobility is made clear. Combustion powered vehicles utilizing the in situ produced methane/oxygen are proposed as a means for meeting the surface mobility requirement. Nuclear thermal rocket propulsion is suggested as a means to improve mission capability. L.K.S.

A91-21464#
HUMAN PLANETARY EXPLORATION STRATEGY FEATURING HIGHLY DECOUPLED ELEMENTS AND CONSERVATIVE PRACTICES
BENTON C. CLARK (Martin Marietta Corp., Astronautics Group, Denver, CO) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 13 p.
(AIAA PAPER 91-0328) Copyright

Mission designs which are fundamentally in accordance with a lowest common denominator approach as well as more ambitious enhancements to the core design are discussed. This approach is based upon a modular vehicle design which is straightforwardly assembled by docking maneuvers and intra-vehicular outfitting. An overall strategy for parallel development of transportation vehicles and associated capabilities for human travel to Mars and the moon is presented which accomodates the desired characteristics. It is noted that this strategy builds upon and emulates the proven success of the Apollo Program strategies including the division of the mission into discrete, self-contained elements with 'clean' interfaces; the incorporation of conservative design using redundancy and independent fall-back modes; and the parallel developments of hardware elements. L.K.S.

A91-25832
HUMANS TO MARS - CAN WE JUSTIFY THE COST?
CARL SAGAN (Cornell University, Ithaca, NY) Planetary Report (ISSN 0736-3680), vol. 11, Jan.-Feb. 1991, p. 4-7.
Copyright

The argument over the justification of human space exploration, with reference to the goals stated in SEI, is outlined. It is noted that NASA currently estimates SEI to cost $500 billion over the next 30 years and that this would essentially double NASA's present budget. A number of arguments commonly used to justify this expenditure are reviewed. These include increased knowledge of planetary geology and environmental sciences, spin-off technology, and educational incentives. It is suggested that, while the value of committing enormous anounts of funding to any of these projects is currently under debate, a number of 'less-tangible' benefits provide a persuasive argument for the pursuit of such programs at a time of budgetary constraints and competing social needs.
L.K.S.

A91-27566
CAN SPACE EXPLORATION SURVIVE THE END OF THE COLD WAR?
BRUCE MURRAY (California Institute of Technology, Pasadena) Space Policy (ISSN 0265-9646), vol. 7, Feb. 1991, p. 23-34.
Copyright

The achievements in space exploration since 1986 are reviewed. It is argued that the first age of space exploration was driven by competition between the U.S. and the USSR. With the apparent close of the Cold War, it is possible that a necessary shift of attention to domestic issues in most nations will cause a hiatus in space exploration. It is thus suggested that a future space exploration program of proper proportion will only be achieved if international cooperation is achieved on a large scale and backed by the necessary political will. It is also suggested that a Mars mission can provide a focus for space exploration well into the next century.
L.K.S.

A91-27578
ECONOMICAL SPACE EXPLORATION SYSTEMS ARCHITECTURES
GORDON R. WOODCOCK (Boeing Aerospace and Electronics, Huntsville, AL) IN: Engineering, construction, and operations in space II; Proceedings of Space 90, the Second International Conference, Albuquerque, NM, Apr. 22-26, 1990. Vol. 1. New York, American Society of Civil Engineers, 1990, p. 19-32.
Copyright

Economical initial architectures are derived by zero-basing and the comprehensive application of hardware and software commonality. It is noted that there is much inheritance from lunar systems to Mars systems, as well as significant inheritance from transpretation systems to surface systems. Of the advanced propulsion technologies applicable to Mars missions, electric propulsion seems to be more cost effective than high-thrust nuclear propulsion. Electric propulsion trip times are found to be competitive and to support a crew rotation and resupply operations mode for Mars which is supportable by high-thrust systems only in the opposition profile model. It is concluded that strategic provisions for growth and evolution will yield sustainable architectures, making it possible to look forward to a sufficiently large human presence on other planets to accomplish thorough exploration and start permanent settlements.
B.J.

A91-27710
ARTIFICIAL GRAVITY RESEARCH FACILITY OPTIONS
SUSAN K. ROSE and TIMOTHY L. STROUP (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) IN: Engineering, construction, and operations in space II; Proceedings of Space 90, the Second International Conference, Albuquerque, NM, Apr. 22-26, 1990. Vol. 2. New York, American Society of Civil Engineers, 1990, p. 1354-1363. refs
Copyright

On a long duration manned mission to Mars, the physiological changes caused by microgravity may be counteracted by artificial gravity. This paper evaluates several different classes of research options - a centrifuge, a free-flying animal facility, and a rotating manned spacecraft. Relative comparisons are made based on the initial constraints imposed on the facility, the operational restrictions for maintaining a healthy crew, based on research to date, and the science research requirements. The science requirements focus on the three primary physiological systems altered by microgravity - cardiovascular deconditioning, calcium loss, and muscle degradation. Significant design drivers, as well as high priority research areas and a recommended design approach are identified.
Author

N89-29409# Joint Publications Research Service, Arlington, VA.
JUSTIFICATION FOR MANNED MARS MISSION, TECHNICAL OPTIONS FOR FLIGHT
V. GLUSHKO, YU. SEMENOV, and L. GORSHKOV *In its* JPRS Report: Science and Technology. USSR: Space p 28-31 18 Jan. 1989 Transl. into ENGLISH from Pravda, (Moscow, USSR), 24 May 1988 p 3
Copyright Avail: NTIS HC A04/MF A01

Justifications are presented for and against manned exploration of Mars. Responses are given to a letter published in Pravda by a Soviet professor by the Soviet citizentry. The kinds of technical possibilities at USSR disposal are examined, along with the kind of spacecraft which could deliver man from planet to planet.
E.R.

N90-26026*# Maryland Univ., College Park. Dept. of Aerospace Engineering.
PROJECT EXODUS Final Report, 23 Jan. - 14 May 1990
RODNEY BRYANT, comp. and ed., JENNIFER DILLON, comp. and ed., GEORGE GREWE, comp. and ed., JIM MCMORROW, comp. and ed., CRAIG MELTON, comp. and ed., GERALD RAINEY, comp. and ed., JOHN RINKO, comp. and ed., DAVID SINGH, comp. and ed., and TZU-LIANG YEN, comp. and ed. May 1990 200 p
(Contract NGT-21-002-800)
(NASA-CR-186836; NAS 1.26:186836; ENAE-412; UM-AERO-90-28) Avail: NTIS HC A09/MF A02 CSCL 22A

A design for a manned Mars mission, PROJECT EXODUS is presented. PROJECT EXODUS incorporates the design of a hypersonic waverider, cargo ship and NIMF (nuclear rocket using indigenous Martian fuel) shuttle lander to safely carry out a three to five month mission on the surface of Mars. The cargo ship transports return fuel, return engine, surface life support, NIMF shuttle, and the Mars base to low Mars orbit (LMO). The cargo ship is powered by a nuclear electric propulsion (NEP) system which allows the cargo ship to execute a spiral trajectory to Mars. The waverider transports ten astronauts to Mars and back. It is launched from the Space Station with propulsion provided by a chemical engine and a delta velocity of 9 km/sec. The waverider performs an aero-gravity assist maneuver through the atmosphere of Venus to obtain a deflection angle and increase in delta velocity. Once the waverider and cargo ship have docked the astronauts will detach the landing cargo capsules and nuclear electric power plant and remotely pilot them to the surface. They will then descend to the surface aboard the NIMF shuttle. A dome base will be quickly constructed on the surface and the astronauts will conduct an exploratory mission for three to five months. They will return to Earth and dock with the Space Station using the waverider.
Author

N90-26027*# Maryland Univ., College Park. Dept. of Aerospace Engineering.
TERRAPIN TECHNOLOGIES MANNED MARS MISSION PROPOSAL Report, 23 Jan. - 14 May 1990
MICHAEL AMATO, HEATHER BRYANT, RODNEY COLEMAN, CHRIS COMPY, PATRICK CROUSE, JOE CRUNKLETON, EDGAR HURTADO, EIRIK IVERSON, MIKE KAMOSA, LAURI KRAFT, ed. and comp. et al. May 1990 208 p
(Contract NGT-21-002-800)
(NASA-CR-186838; NAS 1.26:186838; ENAE-412; UM-AERO-90-27) Avail: NTIS HC A10/MF A02 CSCL 22A

A Manned Mars Mission (M3) design study is proposed. The purpose of M3 is to transport 10 personnel and a habitat with all required support systems and supplies from low Earth orbit (LEO) to the surface of Mars and, after an eight-man surface expedition of 3 months, to return the personnel safely to LEO. The proposed hardware design is based on systems and components of demonstrated high capability and reliability. The mission design builds on past mission experience, but incorporates innovative design approaches to achieve mission priorities. Those priorities, in decreasing order of importance, are safety, reliability, minimum personnel transfer time, minimum weight, and minimum cost. The design demonstrates the feasibility and flexibility of a Waverider transfer module. Author

N91-18138*# Maryland Univ., College Park.
PROJECT EXODUS
In USRA, Proceedings of the 6th Annual Summer Conference: NASA/USRA University Advanced Design Program p 105-110 Nov. 1990
Avail: NTIS HC/MF A14 CSCL 22A

Project Exodus is an in-depth study to identify and address the basic problems of a manned mission to Mars. The most important problems concern propulsion, life support, structure, trajectory, and finance. Exodus will employ a passenger ship, cargo ship, and landing craft for the journey to Mars. These three major components of the mission design are discussed separately. Within each component the design characteristics of structures, trajectory, and propulsion are addressed. The design characteristics of life support are mentioned only in those sections requiring it. Author

N91-18139*# Maryland Univ., College Park.
MANNED MARS MISSION
In USRA, Proceedings of the 6th Annual Summer Conference: NASA/USRA University Advanced Design Program p 111-116 Nov. 1990
Avail: NTIS HC/MF A14 CSCL 22A

Terrapin Technologies proposes a Manned Mars Mission design study. The purpose of the Manned Mars Mission is to transport ten people and a habitat with all required support systems and supplies from low Earth orbit (LEO) to the surface of Mars and, after an expedition of three months to return the personnel safely to LEO. The proposed hardware design is based on systems and components of demonstrated high capability and reliability. The mission design builds on past mission experience but incorporates innovative design approaches to achieve mission priorities. These priorities, in decreasing order of importance, are safety, reliability, minimum personnel transfer time, minimum weight, and minimum cost. The design demonstrates the feasibility and flexibility of a waverider transfer module. Information is given on how the plan meets the mission requirements. Author

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ASTRODYNAMICS

Includes powered and free-flight trajectories; and orbital and launching dynamics.

A84-39240
AEROBRAKING AND AEROCAPTURE FOR MARS MISSIONS
J. R. FRENCH IN: The case for Mars; Proceedings of the Conference, Boulder, CO, April 29-May 2, 1981. San Diego, CA, Univelt, Inc., 1984, p. 245-250. refs
Copyright

The technique of 'aerobraking' uses drag during successive passes through the upper atmosphere to circularize a highly elliptical orbit. A relatively low amount of energy is removed per pass. 'Aerocapture' transfers a vehicle into a closed stable orbit from a hyperbolic flyby trajectory. This technique eliminates all the energy in one pass. It requires, however, a higher degree of technology than the first technique, because of the precise control requirements involved. Details regarding the use of both techniques in Mars missions are discussed. It is found that aerocapture has a number of substantial advantages. The mass delivered to low circular orbit is increased substantially. It is concluded that the use of modern technology in aerodynamic braking offers great potential in the reduction of launch mass requirements for Mars missions. G.R.

A90-11016*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
ATMOSPHERIC ENVIRONMENT DURING MANEUVERING DESCENT FROM MARTIAN ORBIT
MICHAEL E. TAUBER, JEFFREY V. BOWLES (NASA, Ames Research Center, Moffett Field, CA), and LILY YANG (Sterling Software, Inc., Palo Alto, CA) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 26, Sept.-Oct. 1989, p. 330-337. refs
Copyright

This paper presents an analysis of the atmospheric maneuvering capability of a vehicle designated to land on the Martian surface, together with an analysis of the entry environment encountered by the vehicle. A maximum lift/drag ratio of 2.3 was used for all trajectory calculations. The maximum achievable lateral ranges varied from about 3400 km to 2500 km for entry velocities of 5 km/s (from a highly elliptical Martian orbit) and 3.5 km/s (from a low-altitude lower-speed orbit), respectively. It is shown that the peak decelerations are an order of magnitude higher for the 5-km/s entries than for the 3.5-km/s entries. The vehicle entering at 3.5 km/s along a gliding trajectory encountered a much more benign atmospheric environment. In addition, the glider's peak deceleration was found to be only about 0.7 earth g, making the shallow flight path ideal for manned vehicles whose crews might be physically weakened by the long voyage to Mars. I.S.

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GROUND SUPPORT SYSTEMS AND FACILITIES (SPACE)

Includes launch complexes, research and production facilities; ground support equipment, e.g., mobile transporters; and simulators.

A84-39239
SURFACE SAMPLING SYSTEMS
D. S. CROUCH (Martin Marietta Aerospace, Denver, CO) IN: The case for Mars; Proceedings of the Conference, Boulder, CO, April 29-May 2, 1981. San Diego, CA, Univelt, Inc., 1984, p. 233-244.
(AAS PAPER 81-245) Copyright

In the future, missions concerned with sampling operations of the Martian surface will include a search for resources necessary to support the potential manned colonization of the planet. The present investigation has the objective to provide a summary of the capabilities of sampling systems which have been previously used during lunar and Mars missions. Suggestions are also made regarding additional systems which could be employed for future missions, both manned and unmanned. The lunar surveyor spacecraft is considered along with the Apollo lunar surface drill, Apollo lunar surface drill components, a lunar sub-surface sample from a three-meter core hole, Luna 16 and 20 lunar surface samplers (Russian), mass Viking surface sampler subsystem components, and a Luna 24 lunar surface sampler (Russian). Surface samplers considered for future Mars missions are related to a surface roving vehicle for the collection of samples in connection with sample return missions. G.R.

A88-16096#
LIFE SCIENCE TECHNOLOGY FOR MANNED MARS MISSIONS
THOMAS R. MEYER (Boulder Center for Science and Policy, CO)

IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 10 p. refs
(IAF PAPER 87-437)

The paper discusses existing life science technology and on-going R & D activities applicable to the support of manned Mars missions. Emphasis is placed on the technologies which can utilize the resources (water, oxygen, and a buffer gas composed of nitrogen and argon) that can be obtained from the Mars environment. It is noted that the availability of local resources would provide inputs to closed life support systems, easing the requirements and effects of total closure and compensating for leakage due to crew egress and ingress. K.K.

A89-45763
CANDOR CHASMA CAMP
ETHAN WILSON CLIFFTON IN: Engineering, construction, and operations in space; Proceedings of the Space '88 Conference, Albuquerque, NM, Aug. 29-31, 1988. New York, American Society of Civil Engineers, 1988, p. 457-464. refs
Copyright

The paper proposes a camp on Mars, in the Coprates region of the Valles Marineris rift, just below the equator on Candor Mensa, 6 deg 12 min S, 73 deg 30 min W. Options for survival technology are discussed, with attention given to energy and equipment requirements. Successful mission strategy requires the participation of civil engineers to create adaptive planning and technology for an expanding network of camps among the plateaus and valleys of Mars. B.J.

A90-16681
BUILDING MARS HABITATS USING LOCAL MATERIALS
BRUCE A. MACKENZIE IN: The case for Mars III: Strategies for exploration - General interest and overview. San Diego, CA, Univelt, Inc., 1989, p. 575-586. refs
(AAS PAPER 87-216) Copyright

The basic problems that will be encountered in building and living on Mars are outlined, and various kinds of habitats that may be utilized are described. Barrel vaults are examined as first habitats, and the brick, mortar, fill, scrap, imported materials, glass blocks, and fiberglass used in their construction are discussed. The design of more advanced, multistory condominiums on Mars is addressed. C.D.

A90-16682* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
THE USE OF INFLATABLE HABITATION ON THE MOON AND MARS
MICHAEL ROBERTS (NASA, Johnson Space Center, Houston, TX) IN: The case for Mars III: Strategies for exploration - General interest and overview. San Diego, CA, Univelt, Inc., 1989, p. 587-593.
(AAS PAPER 87-217) Copyright

A recurring element in futuristic lunar and Mars base scenarios, the inflatable dome has some clear advantages over rigid modules: low mass, high volume, and good packing efficiency at launch. This paper explores some of the engineering issues involved in designing such a structure. Author

A90-16684* Martin Marietta Corp., Denver, CO.
TOOL AND EQUIPMENT REQUIREMENTS FOR HUMAN HABITATION OF MARS
MICHAEL G. THORNTON (Martin Marietta Corp., Denver, CO) IN: The case for Mars III: Strategies for exploration - General interest and overview. San Diego, CA, Univelt, Inc., 1989, p. 607-616.
(Contract NAS8-37126)
(AAS PAPER 87-219) Copyright

This paper presents an examination of requirements and design considerations for tools and equipment to establish a continuous human presence on Mars. Specific problems addressed include; manufacturing in zero gravity conditions, with or without an atmosphere, temperature considerations, and use of tools by astronauts on Mars or while traveling to or from Mars. A design for a salvage concept for equipment landed on Mars is presented. Author

A90-16685
AN OVERVIEW OF MARS SURFACE MOBILITY JUSTIFICATION AND OPTIONS
JAMES R. FRENCH (World Space Foundation, South Pasadena, CA) IN: The case for Mars III: Strategies for exploration - General interest and overview. San Diego, CA, Univelt, Inc., 1989, p. 619-632. refs
(AAS PAPER 87-220) Copyright

A brief overview of various Mars mobility options is presented. The vehicle concepts addressed include surface rovers, aircraft, and ballistic or boost-glide vehicles. Power sources for mobility are also considered. C.D.

A90-16687
MARS GLOBAL EXPLORATION VEHICLE
J. MARK MCCANN, MARK J. SNAUFER, and ROBERT J. SVENSON IN: The case for Mars III: Strategies for exploration - General interest and overview. San Diego, CA, Univelt, Inc., 1989, p. 647-663. refs
(AAS PAPER 87-222) Copyright

Any establishment of a permanent base on Mars will require a transportation system to facilitate the logistical support of the base and the scientific exploration of the planet. The design of such a system of transportation wil require innovative approaches to powering the vehicles and providing life support. Power, life support, and vehicle components are analyzed and a possible vehicle configuration proposed. Emphasis is placed on design criteria and physical data needed to fulfill the global requirements of such a system. Author

A90-38894
DEVELOPMENT OF AUTONOMOUS SYSTEMS
TAKEO KANADE (Carnegie-Mellon University, Pittsburgh, PA) IN: Applications of artificial intelligence VII; Proceedings of the Meeting, Orlando, FL, Mar. 28-30, 1989. Part 1. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1989, p. 569-573. refs
Copyright

Two autonomous land vehicles are discussed: (1) the 'navigation laboratory', or Navlab commercial van-based vehicle for navigational artificial vision research, which carries an extensive sensor and instrumentation suite, together with human monitors; and (2) the Autonomous Mobile Exploration Robot, or 'Ambler', which is a walking robot for prospective Mars exploration that employs six legs joined coaxially at the fulcrum of their shoulder joints. Each leg of the Ambler consists of two shoulder and elbow joints that move in a horizontal plane to the position of the leg, and a prismatic joint at the end of the elbow link which effects a vertical telescoping motion for foot extention or retraction. O.C.

A90-49380* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SPACE RADIATION SHIELDING FOR A MARTIAN HABITAT
LISA C. SIMONSEN, JOHN E. NEALY, LAWRENCE W. TOWNSEND, and JOHN W. WILSON (NASA, Langley Research Center, Hampton, VA) SAE, Intersociety Conference on Environmental Systems, 20th, Williamsburg, VA, July 9-12, 1990. 10 p. refs
(SAE PAPER 901346) Copyright

Radiation shielding analyses are performed for a candidate Mars base habitat. The Langley cosmic ray transport code and the Langley nucleon transport code are used to quantify the transport and attenuation of galactic cosmic rays and solar flare protons through both the Martian atmosphere and regolith shielding. Doses at the surface and at various altitudes were calculated in a previous study using both a high-density and a low-density Mars atmosphere model. This study extends the previous low-density results to include the further transport of the ionizing radiation that reaches the surface through additional shielding provided by

Martian regolith. A four-compound regolith model, which includes SiO2, Fe2O3, MgO, and CaO, was selected based on the chemistry of the Viking 1 Lander site. The spectral fluxes of heavy charged particles and the corresponding dosimetric quantities are computed for a series of thicknesses in the shield media after traversing the atmosphere. These data are then used as input to algorithms for a specific shield geometry. The results are presented as the maximum dose received in the center of the habitat versus various shield thicknesses for a base at an altitude of 0 km and 8 km. Author

A91-10147*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SITE CHARACTERIZATION ROVER MISSIONS
DONNA SHIRLEY PIVIROTTO (JPL, Pasadena, CA) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 15 p. refs
(AIAA PAPER 90-3785) Copyright

Concepts for site characterization rovers capable of efficient operation on Mars with human supervision from earth are discussed. In particular, attention is given to strategies for developing and evaluating the necessary technology for implementing the roving vehicles and process technologies required for a systematic and integrated implementation of technologically advanced rovers. A vehicle testbed program is also described. V.L.

A91-20230
DEVELOPMENT OF A MARTIAN SURFACE MODEL FOR SIMULATION OF VEHICLE DYNAMICS AND MOBILITY
DONALD H. CRONQUIST, JR., LOUIS S. MCTAMANEY (FMC Corporate Technology Center, Santa Clara, CA), and JOHN J. NITAO IN: Mobile robots IV; Proceedings of the Meeting, Philadelphia, PA, Nov. 6, 7, 1989. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 157-167.
Copyright

A high resolution Mars surface model is being developed for simulation of vehicle dynamics, mobility and navigation capabilities. The model provides a topological representation of surface features and is suitable for interface with dynamic simulations of Mars Rover vehicles including models for wheel-soil interaction and vision systems. Portions of the surface model have been completed and can be interfaced with other portions of an overall vehicle performance assessment system also being developed for the Mars Rover program. Author

A91-20231
COMPUTER MODELLING - A STRUCTURED LIGHT VISION SYSTEM FOR A MARS ROVER
DONALD H. CRONQUIST, JR. (FMC Corporate Technology Center, Santa Clara, CA) and JOHN J. NITAO IN: Mobile robots IV; Proceedings of the Meeting, Philadelphia, PA, Nov. 6, 7, 1989. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 168-177.
Copyright

A computer model has been developed as a tool for evaluating the use of structured light systems for local navigation of the Mars Rover. The system modeled consists of two laser sources emanating flat, widened beams with a single camera to detect stripes on the terrain. The terrain elevation extracted from the stripe information goes to updating a local terrain map which is processed to determine impassable regions. The system operates with the beams and cameras fixed except, now and then, the beams are vertically panned to completely refresh the local map. An efficient surface removal algorithm determines the points on the terrain surface hit by rays in the bundle. The power of each reflected ray that falls on each pixel of the camera is computed using well-known optical laws. Author

A91-26619* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
AUTONOMOUS NAVIGATION AND CONTROL OF A MARS ROVER
D. P. MILLER, D. J. ATKINSON, B. H. WILCOX, and A. H. MISHKIN (JPL, Pasadena, CA) IN: Automatic control in aerospace; IFAC Symposium, Tsukuba, Japan, July 17-21, 1989, Selected Papers. Oxford, England and New York, Pergamon Press, 1990, p. 111-114. refs
Copyright

A Mars rover will need to be able to navigate autonomously kilometers at a time. This paper outlines the sensing, perception, planning, and execution monitoring systems that are currently being designed for the rover. The sensing is based around stereo vision. The interpretation of the images use a registration of the depth map with a global height map provided by an orbiting spacecraft. Safe, low energy paths are then planned through the map, and expectations of what the rover's articulation sensors should sense are generated. These expectations are then used to ensure that the planned path is correctly being executed. Author

A91-27615
A PRELIMINARY EVALUATION OF EXTRATERRESTRIAL BUILDING SYSTEMS
PHILIP J. RICHTER and RICHARD M. DRAKE (Fluor Daniel, Inc., Irvine, CA) IN: Engineering, construction, and operations in space II; Proceedings of Space 90, the Second International Conference, Albuquerque, NM, Apr. 22-26, 1990. Vol. 1. New York, American Society of Civil Engineers, 1990, p. 409-418. refs
Copyright

The general purpose of this paper is to conduct a preliminary examination of the concepts for habitats to be used for lunar and Martian bases in the intermediate stage of base occupancy and development. Four basic structural system types encompassing six concepts are examined and evaluated. The contribution of the work discussed is to help develop evaluation methodology, to set up straw man concepts for purposes of identifying trade studies, and to set the stage for further evaluations, which it is suggested take place, at least partially, in a workshop format. Author

A91-27622
A LUNAR OUTPOST SURFACE SYSTEMS ARCHITECTURE
L. A. PIENIAZEK and L. TOUPS (Lockheed Engineering and Sciences Co., Houston, TX) IN: Engineering, construction, and operations in space II; Proceedings of Space 90, the Second International Conference, Albuquerque, NM, Apr. 22-26, 1990. Vol. 1. New York, American Society of Civil Engineers, 1990, p. 480-489.
Copyright

A concept has been developed that defines mission objectives, system concepts, surface elements, and outpost layout using a systematic approach for a lunar outpost surface architecture. NASA has been studying possible options for the human exploration of the solar system that involve outposts for the moon and Mars. These include elements that support mission objectives directly such as science equipment and elements that support of the base itself such as habitation, communications, power, and space transportation. The development of appropriate architectures for planet surface systems is discussed, focusing on top-level structure and integration. The outpost facilities can also take care of the collection, reduction and transmission of data from monitoring equipment. In addition, human factors and biomedical research can demonstrate the capability of humans to perform on extraterrestrial surfaces prior to committing to risky endeavors. R.E.P.

A91-27650
HUMAN OPERATIONS, RESOURCES AND BASES ON MARS
BRUCE M. CORDELL (General Dynamics Corp., Space Systems Div., San Diego, CA) IN: Engineering, construction, and operations in space II; Proceedings of Space 90, the Second International Conference, Albuquerque, NM, Apr. 22-26, 1990. Vol. 1. New York, American Society of Civil Engineers, 1990, p. 759-768. refs
Copyright

This paper discusses various activities involving the establishment and operation of surface facilities on Mars to support habitation, surface explorations, laboratory science, and resource

use. After a review of a number of relevant atmospheric and surface environmental parameters, strategies for Mars exploration are presented. Several sites on Mars, based on known geology and topography are evaluated for potential use as human base sites. Water and other usable resources stored in the Mars atmosphere are described as well as their extraction processes and possible products. Magnesium and/or iron appear to be available as construction metals. The atmosphere and surface of Mars are discussed in the context of base construction operations. R.E.P.

A91-27692
ANTARCTIC TESTBED FOR EXTRATERRESTRIAL OPERATION AND TECHNOLOGY
LARRY BELL and DEBORAH J. NEUBEK (Houston, University, TX) IN: Engineering, construction, and operations in space II; Proceedings of Space 90, the Second International Conference, Albuquerque, NM, Apr. 22-26, 1990. Vol. 2. New York, American Society of Civil Engineers, 1990, p. 1188-1197.
Copyright

It is proposed that the physical similarities between the Antarctic environment and the moon and Mars environments as well as parallels between the general nature of crew activities be used in the planning of moon and Mars missions. Emphasis is placed on operational and technological areas such as operations and logistics; facility planning; design and construction; utility systems; and the selection, design, and development of automatic and telerobotic systems. An international research and technology demonstration facility in Antarctica is planned by the Saskawa Internatonal Center for Space Architecture. The Antarctic Planetary Testbed (APT) program will provide a basis for new insights into planning for moon and Mars missions. O.G.

A91-27702* New Mexico Univ., Albuquerque.
PRELIMINARY ASSESSMENT OF THE POWER REQUIREMENTS OF A MANNED ROVER FOR MARS MISSIONS
MOHAMED S. EL-GENK, NICHOLAS J. MORLEY (New Mexico, University, Albuquerque), ROBERT CATALDO, and HARVEY BLOOMFIELD (NASA, Lewis Research Center, Cleveland, OH) IN: Engineering, construction, and operations in space II; Proceedings of Space 90, the Second International Conference, Albuquerque, NM, Apr. 22-26, 1990. Vol. 2. New York, American Society of Civil Engineers, 1990, p. 1278-1287. refs
(Contract NAG3-992)
Copyright

A preliminary study to determine the total mass and power requirements of a manned Mars rover is presented. Estimates of the power requirements for the nuclear reactor power system are determined as functions of the number of crew members, the emergency return trip scenario in case of a total malfunction of the reactor system, the cruising speed and range of the vehicle, and the specific mass of the power system. It is shown that the cruising speed of the vehicle and the soil traction factor significantly affect the traversing power requirement and therefore the mass of the nuclear power system. The cruising speed of the vehicle must be limited to 14.5 and 24 km/hr for power system specific masses of 150 kg/kWe and 50 kg/kWe, respectively, for the nuclear power system mass not to exceed 50 percent of the total mass of the rover. R.E.P.

15

LAUNCH VEHICLES AND SPACE VEHICLES

Includes boosters; operating problems of launch/space vehicle systems; and reusable vehicles.

A90-16673
MARS LANDING AND LAUNCH REQUIREMENTS AND A POSSIBLE APPROACH
JAMES R. FRENCH (World Space Foundation, South Pasadena, CA) IN: The case for Mars III: Strategies for exploration - General interest and overview. San Diego, CA, Univelt, Inc., 1989, p. 413-420. refs
(AAS PAPER 87-207) Copyright

A design for a Mars aerocapture and landing vehicle is described and some of the rationale behind the concept is presented. The vehicle is a bent biconic shape which will deliver a lift over drag ratio between 0.6 and 1.5 depending upon trim angle of attack. Given sufficiently accurate approach navigation, this vehicle can reduce landing errors to the order of Mars map errors (say 5 km), a substantial improvement over previous vehicles. Author

A90-16674* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
HEAVY LIFT VEHICLES FOR TRANSPORTATION TO A LOW EARTH ORBIT SPACE STATION FOR ASSEMBLY OF A HUMAN TO MARS MISSION
FRANK E. SWALLEY (NASA, Marshall Space Flight Center, Huntsville, AL) IN: The case for Mars III: Strategies for exploration - General interest and overview. San Diego, CA, Univelt, Inc., 1989, p. 421-431. refs
(AAS PAPER 87-208) Copyright

Heavy lift vehicle configurations are proposed which will meet the requirements for transporting the elements of a Human to Mars Mission to a low earth orbit Space Station for assembly. Both near term derivative type vehiles as well as advanced technology vehicles are considered. The capability of these vehicles to accommodate the precursor missions are also examined. The implications on launch vehicle payload accommodation design and orbital operations are discussed. Author

A91-10034*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
A NETWORK OF SMALL LANDERS ON MARS
JAMES D. BURKE and ROBERT N. MOSTERT (JPL, Pasadena, CA) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 7 p. refs
(AIAA PAPER 90-3577) Copyright

This paper describes a class of small landers that could form part of a global network of scientific instrumentation on Mars. Two types of landers are considered: penetrators that implant instruments a few meters beneath the surface, and rough landers that may hit the surface at speeds up to tens of m/sec and survive through the use of impact-limiting techniques. Because some scientific objectives, such as seismic and meteorological investigations, require durations of months and years lander designs giving long lifetimes in the Martian environment are needed. This paper describes both past and more recent work at JPL toward this goal. Author

16

SPACE TRANSPORTATION

Includes passenger and cargo space transportation, e.g., shuttle operations; and space rescue techniques.

N90-26036*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
THE EFFECT OF INTERPLANETARY TRAJECTORY OPTIONS ON A MANNED MARS AEROBRAKE CONFIGURATION
ROBERT D. BRAUN, RICHARD W. POWELL, and LIN C. HARTUNG Washington Aug. 1990 79 p
(NASA-TP-3019; L-16661; NAS 1.60:3019) Avail: NTIS HC A05/MF A01 CSCL 22B

Manned Mars missions originating in low Earth orbit (LEO) in the time frame 2010 to 2025 were analyzed to identify preferred mission opportunities and their associated vehicle and trajectory characteristics. Interplanetary and Mars atmospheric trajectory options were examined under the constraints of an initial manned exploration scenario. Two chemically propelled vehicle options were considered: (1) an all propulsive configuration, and (2) a configuration which employs aerobraking at Earth and Mars with low lift/drag (L/D) shapes. Both the interplanetary trajectory options as well as the Mars atmospheric passage are addressed to provide a coupled trajectory simulation. Direct and Venus swingby interplanetary transfers with a 60 day Mars stopover are considered. The range and variation in both Earth and Mars entry velocity are also defined. Two promising mission strategies emerged from the study: (1) a 1.0 to 2.0 year Venus swingby mission, and (2) a 2.0 to 2.5 year direct mission. Through careful trajectory selection, 11 mission opportunities are identified in which the Mars entry velocity is between 6 and 10 km/sec and Earth entry velocity ranges from 11.5 to 12.5 km/sec. Simulation of the Earth return aerobraking maneuver is not performed. It is shown that a low L/D configuration is not feasible for Mars aerobraking without substantial improvements in the interplanetary navigation system. However, even with an advanced navigation system, entry corridor and aerothermal requirements restrict the number of potential mission opportunities. It is also shown that for a large blunt Mars aerobrake configuration, the effects of radiative heating can be significant at entry velocities as low as 6.2 km/sec and will grow to dominate the aerothermal environment at entry velocities above 8.5 km/sec. Despite the additional system complexity associated with an aerobraking vehicle, the use of aerobraking was shown to significantly lower the required initial LEO weight. In comparison with an all propulsive mission, savings between 19 and 59 percent were obtained depending upon launch date. Author

18

SPACECRAFT DESIGN, TESTING AND PERFORMANCE

Includes satellites; space platforms; space stations; spacecraft systems and components such as thermal and environmental controls; and attitude controls.

A84-39229
MANNED MARS MISSION LANDING AND DEPARTURE SYSTEMS
D. B. CROSS and A. J. BUTTS (Martin Marietta Aerospace, Denver, CO) IN: The case for Mars; Proceedings of the Conference, Boulder, CO, April 29-May 2, 1982. San Diego, CA, Univelt, Inc., 1984, p. 75-82.
(AAS PAPER 81-233) Copyright

The implementation of the Mars landing and departure strategies considered to date would require large amounts of propellants. For this reason, these strategies do not appear efficient enough to support manned Mars exploration missions. An investigation is conducted of the involved systems and their relation to other elements of the Mars mission, taking into account possibilities for saving energy. Attention is given to the impact of sample size on system design, landing and departure modes, an aerobraking concept sequence, drag polars, lifting vehicle concepts, a Mars airplane, and a Mars ascent vehicle. It appears that considerable advantages to manned exploration can be obtained from orbiting stations at both earth and Mars. Continued development of aerocapture and aeromaneuvering vehicles offers the greatest potential in efficient energy usage for orbit insertion, circularization, and landing in planetary atmospheres. The manufacture of propellants on the surface of Mars would provide for large savings in energy. G.R.

A84-39231
THE EXTERNAL TANK SCENARIO - UTILIZATION OF THE SHUTTLE EXTERNAL TANK FOR EARTH TO MARS TRANSIT
T. C. TAYLOR IN: The case for Mars; Proceedings of the Conference, Boulder, CO, April 29-May 2, 1981. San Diego, CA, Univelt, Inc., 1984, p. 109-127. refs
(AAS PAPER 81-236) Copyright

The developments occurring in the case of the Prudhoe Bay field on the North Slope of Alaska are compared to a situation which might arise if economically valuable resouces would be found on Mars. The necessity to develop an oil field in the Arctic wasteland as economically as possible had led to the reuse of packing crates at the remote base. A similar situation might develop if, for instance, a valuable mineral urgently needed on earth should be found on Mars. Approaches are discussed by which the External Tank (ET) of the Space Shuttle might provide an aid of particular cost-effectiveness in the processes required for large scale resource development of Mars. Attention is given to ET as a raw material resource, the ET use in facility construction, and ET as a component in interplanetary vehicles. G.R.

A91-27711* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
VARIABLE GRAVITY RESEARCH FACILITY - A CONCEPT
PAUL F. WERCINSKI, MARCIE A. SMITH, ROBERT G. SYNNESTVEDT, and ROBERT G. KELLER (NASA, Ames Research Center, Moffett Field, CA) IN: Engineering, construction, and operations in space II; Proceedings of Space 90, the Second International Conference, Albuquerque, NM, Apr. 22-26, 1990. Vol. 2. New York, American Society of Civil Engineers, 1990, p. 1364-1373.
Copyright

Is human exposure to artificial gravity necessary for Mars mission success, and if so, what is the optimum means of achieving artificial gravity? Answering these questions prior to the design of a Mars vehicle would require construction and operation of a dedicated spacecraft in low earth orbit. This paper summarizes the study results of a conceptual design and operations scenario for such a spacecraft, called the Variable Gravity Research Facility (VGRF). Author

N90-17667*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
PRELIMINARY INVESTIGATION OF PARAMETER SENSITIVITIES FOR ATMOSPHERIC ENTRY AND AEROBRAKING AT MARS
MARY C. LEE and WILLIAM T. SUIT Sep. 1989 30 p
(NASA-TM-101607; NAS 1.15:101607) Avail: NTIS HC A03/MF A01 CSCL 22B

The proposed manned Mars mission will need to be as weight efficient as possible. A way of lowering the weight of the vehicle by using aeroassist braking instead of retro-rockets to slow a craft once it reaches its destination is discussed. The two vehicles studied are a small vehicle similar in size to the Mars Rover Sample Return (MRSR) vehicle and a larger vehicle similar in size to a six-person Manned Mars Mission (MMM) vehicle. Simulated entries were made using various coefficients of lift (C

sub L), coefficients of drag (C sub D), and lift-to-drag ratios (L/D). A range of acceptable flight path angles with their corresponding bank angle profiles was found for each case studied. These ranges were then compared, and the results are reported here. The sensitivity of velocity and acceleration to changes in flight path angle and bank angle is also included to indicate potential problem areas for guidance and navigation system design. Author

20

SPACECRAFT PROPULSION AND POWER

Includes main propulsion systems and components, e.g., rocket engines; and spacecraft auxiliary power sources.

A84-39230
SOLAR ELECTRIC PROPULSION STAGE AS A MARS EXPLORATION TOOL
S. KENT (Delta Vee, Inc., San Jose, CA) IN: The case for Mars; Proceedings of the Conference, Boulder, CO, April 29-May 2, 1981. San Diego, CA, Univelt, Inc., 1984, p. 83-89.
(AAS PAPER 81-234) Copyright

It is pointed out that the Solar Electric Propulsion System (SEPS) is an extremely flexible space transportation system capable of performing high energy and/or extended operations missions. SEPS will utilize ion propulsion produced by the electrostatic expulsion of mercury ions with exhaust velocities of over 30,000 meters per second, compared to a maximum of 5,000 meters per second with chemical propulsion. The required power will be obtained from the SEPS solar array wings. Space missions utilizing SEPS could include the International Comet Mission, a Saturn Orbiter with dual probes, a close solar probe, an asteroid multiple rendezvous mission, and earth orbital missions. Informal analyses have been conducted regarding the employment of SEPS as a Mars exploration tool. Attention is given to trip times from six to nine months delivering 2,000-4,000 kg into Mars parking orbit, or alternatively, a sample return with over 50 kg of Martian rock. G.R.

A90-16675
PROPULSION SYSTEM CONSIDERATIONS/APPROACH FOR FAST TRANSFER TO MARS
PAUL A. HARRIS and FRANK J. PERRY (Rockwell International Corp., Rocketdyne Div., Canoga Park, CA) IN: The case for Mars III: Strategies for exploration - General interest and overview. San Diego, CA, Univelt, Inc., 1989, p. 433-448. refs
(AAS PAPER 87-209) Copyright

The advantages of shorter transit times are discussed, including impact on vehicle design, and crew physiological and psychological effects. A hybrid propulsion system combining nuclear thermal and nuclear electric propulsion is proposed to achieve shorter transit times and provide abundant electrical power at Mars. Preliminary comparisons of this hybrid propulsion option with other options indicate the existence of significant advantages of bimodal nuclear propulsion/power. Propulsion system options for the Manned Mars Mission are examined parametrically to provide an estimate of earth departure (Low Earth Orbit, LEO) mass as a function of transit time to Mars. Author

A90-16676* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
NUCLEAR PROPULSION - A VITAL TECHNOLOGY FOR THE EXPLORATION OF MARS AND THE PLANETS BEYOND
STANLEY K. BOROWSKI (NASA, Lewis Research Center, Cleveland, OH) IN: The case for Mars III: Strategies for exploration - General interest and overview. San Diego, CA, Univelt, Inc., 1989, p. 451-494. Previously announced in STAR as N89-10944. refs
(AAS PAPER 87-210) Copyright

The physics and technology issues and performance potential of various direct thrust fission and fusion propulsion concepts are examined. Next to chemical propulsion the solid core fission thermal rocket (SCR) is the only other concept to be experimentally tested at the power (approx 1.5 to 5.0 GW) and thrust levels (approx 0.33 to 1.11 MN) required for manned Mars missions. With a specific impulse of approx 850 s, the SCR can perform various near-earth, cislunar and interplanetary missions with lower mass and cost requirements than its chemical counterpart. The gas core fission thermal rocket, with a specific power and impulse of approx 50 kW/kg and 5000 s offers the potential for quick courier trips to Mars (of about 80 days) or longer duration exploration cargo missions (lasting about 280 days) with starting masses of about 1000 m tons. Convenient transportation to the outer Solar System will require the development of magnetic and inertial fusion rockets (IFRs). Possessing specific powers and impulses of approx 100 kW/kg and 200-300 kilosecs, IFRs will usher in the era of the true Solar System class spaceship. Even Pluto will be accessible with roundtrip times of less than 2 years and starting masses of about 1500 m tons. Author

A90-16677
APPLICATIONS OF IN-SITU CARBON MONOXIDE-OXYGEN PROPELLENT PRODUCTION AT MARS
W. MITCHELL CLAPP (USAF, Test Pilot School, Edwards AFB, CA) and MICHAEL P. SCARDERA (USAF, Falcon AFB, CO) IN: The case for Mars III: Strategies for exploration - General interest and overview. San Diego, CA, Univelt, Inc., 1989, p. 513-537. refs
(AAS PAPER 87-212) Copyright

Liquid carbon monoxide and liquid oxygen can be manufactured from the Martian atmosphere. Various energy conversion devices using this fuel/oxidizer resource are introduced and evaluated, including fuel cells, diesel cycle engines, gas turbines, and rocket engines. The performance of these engines in a variety of different vehicles suitable for travel at Mars is discussed. Finally, possible missions are shown for vehicles which use in situ manufactured propellants. Author

A90-16688* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
POWER CONSIDERATIONS FOR AN EARLY MANNED MARS MISSION UTILIZING THE SPACE STATION
MARTIN E. VALGORA (NASA, Lewis Research Center, Cleveland, OH) IN: The case for Mars III: Strategies for exploration - General interest and overview. San Diego, CA, Univelt, Inc., 1989, p. 667-679.
(AAS PAPER 87-223) Copyright

Power requirements and candidate electrical power sources were examined for the supporting space infrastructure for an early (2004) manned Mars mission. This two-year mission (60-day stay time) assumed a single six crew piloted vehicle with a Mars lander for four of the crew. The transportation vehicle was assumed to be a hydrogen/oxygen propulsion design with or without large aerobrakes and assembled and checked out on the LEO Space Station. The long transit time necessitated artificial gravity of the crew by rotating the crew compartments. This rotation complicates power source selection. Candidate power sources were examined for the Lander, Mars Orbiter, supporting Space Station, co-orbiting Propellant Storage Depot, and, alternatively, a co-orbiting Propellant Generation (water electrolysis) Depot. Candidates considered were photovoltaics with regenerative fuel cells or batteries, solar dynamics, isotope dynamics, and nuclear power. Author

A90-16689* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
THE SP-100 SPACE REACTOR AS A POWER SOURCE FOR MARS EXPLORATION MISSIONS
LON ISENBERG (JPL, Pasadena, CA) and JACK A. HELLER (NASA, Lewis Research Center, Cleveland, OH) IN: The case for Mars III: Strategies for exploration - General interest and overview. San Diego, CA, Univelt, Inc., 1989, p. 681-695. refs
(AAS PAPER 87-224) Copyright

This paper argues that many of the power requirements of

complex, relatively long-duration space missions such as the exploration of Mars may best be met through the use of power systems which use nuclear reactors as a thermal energy source. The development of such a power system, the SP-100, and its application in Mars mission scenarios is described. The missions addressed include a freighter mission and a mission involving exploration of the Martian surface. C.D.

A90-16690* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
LASER POWER TRANSMISSION CONCEPTS FOR MARTIAN APPLICATIONS
R. J. DE YOUNG, E. J. CONWAY, W. E. MEADOR, and D. H. HUMES (NASA, Langley Research Center, Hampton, VA) IN: The case for Mars III: Strategies for exploration - General interest and overview. San Diego, CA, Univelt, Inc., 1989, p. 697-708. refs
(AAS PAPER 87-225) Copyright
Long-term, highly reliable, flexible power will be required to support many diverse activities on Mars and for rapid development of the Mars environment. The potential of laser power transmission for supporting science, materials processing, transportation, and human habitats is discussed. Some advantageous locations for laser power stations in Mars orbit are developed. Author

N89-13492*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
POWER CONSIDERATIONS FOR AN EARLY MANNED MARS MISSION UTILIZING THE SPACE STATION
MARTIN E. VALGORA 1987 15 p Presented at Case for Mars 3, Boulder, Colo., 18-22 Jul. 1987; sponsored by American Aeronautical Society, JPL, Los Alamos National Lab., Ames Research Center, Lyndon B. Johnson Space Center, George C. Marshall Space Flight Center, Planetary Society
(NASA-TM-101436; E-4472; NAS 1.15:101436) Avail: NTIS HC A03/MF A01 CSCL 10B
Power requirements and candidate electrical power sources were examined for the supporting space infrastructure for an early (2004) manned Mars mission. This two-year mission (60-day stay time) assumed a single six crew piloted vehicle with a Mars lander for four of the crew. The transportation vehicle was assumed to be a hydrogen/oxygen propulsion design with or without large aerobrakes and assembled and checked out on the LEO Space Station. The long transit time necessitated artificial gravity of the crew by rotating the crew compartments. This rotation complicates power source selection. Candidate power sources were examined for the Lander, Mars Orbiter, supporting Space Station, co-orbiting Propellant Storage Depot, and alternatively, a co-orbiting Propellant Generation (water electrolysis) Depot. Candidates considered were photovoltaics with regenerative fuel cells or batteries, solar dynamics, isotope dynamics, and nuclear power. Author

N89-26041*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
ADVANCES IN THIN-FILM SOLAR CELLS FOR LIGHTWEIGHT SPACE PHOTOVOLTAIC POWER
GEOFFREY A. LANDIS, SHEILA G. BAILEY, and DENNIS J. FLOOD 1989 29 p Presented at the International Conference on Space Power, Cleveland, OH, 5-7 Jun. 1989; sponsored by the International Astronautical Federation
(NASA-TM-102017; E-4734; NAS 1.15:102017) Avail: NTIS HC A03/MF A01 CSCL 10A
The present stature and current research directions of photovoltaic arrays as primary power systems for space are reviewed. There have recently been great advances in the technology of thin-film solar cells for terrestrial applications. In a thin-film solar cell the thickness of the active element is only a few microns; transfer of this technology to space arrays could result in ultralow-weight solar arrays with potentially large gains in specific power. Recent advances in thin-film solar cells are reviewed, including polycrystalline copper-indium selenide (CuInSe2) and related I-III-VI2 compounds, polycrystalline cadmium telluride and related II-VI compounds, and amorphous silicon:hydrogen and alloys. The best experimental efficiency on thin-film solar cells to date is 12 percent AMO for CuIn Se2. This efficiency is likely to be increased in the next few years. The radiation tolerance of thin-film materials is far greater than that of single-crystal materials. CuIn Se2 shows no degradation when exposed to 1 MeV electrons. Experimental evidence also suggests that most of all of the radiation damage on thin-films can be removed by a low temperature anneal. The possibility of thin-film multibandgap cascade solar cells is discussed, including the tradeoffs between monolithic and mechanically stacked cells. The best current efficiency for a cascade is 12.5 percent AMO for an amorphous silicon on CuInSe2 multibandgap combination. Higher efficiencies are expected in the future. For several missions, including solar-electric propulsion, a manned Mars mission, and lunar exploration and manufacturing, thin-film photovolatic arrays may be a mission-enabling technology. Author

N90-18480*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ELECTRIC PROPULSION FOR MANNED MARS EXPLORATION
BRYAN PALASZEWSKI *In* Johns Hopkins Univ., The 1989 JANNAF Propulsion Meeting, Volume 1 p 421-435 May 1989
Avail: NTIS HC A25/MF A04 CSCL 21H
Advanced high-power electric propulsion systems can significantly enhance piloted Mars missions. An increase in the science payload delivered to Mars and the reduction of the total Earth-departure mass are the major system-level benefits of electric propulsion. Other potential benefits are the return of the cargo vehicle to Earth orbit and the availability of high power in Mars orbit for high-power science and communications. Parametric analyses for sizing the cargo mission vehicle for Mars exploration missions are presented. The nuclear-electric propulsion system thruster size, power level, mass, propellant type and payload mass capability are considered in these system-level trade studies. Descriptions of the propulsion system selection issues for both ion and MPD thruster technologies are also discussed. On a manned Mars mission, the total launch mass for an unmanned cargo vehicle in low earth orbit (LEO) can be reduced by up to 50 percent over the baseline oxygen/hydrogen propulsion system. Because the cargo vehicle is sent to Mars prior to the manned mission, the trip time for the vehicle is not a critical factor. By taking advantage of the high specific impulse (I sub sp) of an ion or a Magneto-Plasma-Dynamic (MPD) thruster system, the total LEO mass is reduced from 590,000 kg for the oxygen/hydrogen propulsion system to 309,000 kg for the MPD system and 295,000 kg for the ion system. Many factors must be analyzed in the design of a electric propulsion Mars cargo vehicle. The propellant selection, the number of thrusters, the power level and the specific impulse are among the most important of the parameters. To fully address the electric propulsion system design, trade studies for the differing ion and MPD propulsion system configurations (thruster power levels, number of thrusters, propellants and power systems) must be conducted. Author

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CHEMISTRY AND MATERIALS (GENERAL)

A90-16678
DURICRETE AND COMPOSITES CONSTRUCTION ON MARS
ROBERT C. BOYD, PATRICK S. THOMPSON, and BENTON C. CLARK (Martin Marietta Planetary Sciences Laboratory, Denver, CO) IN: The case for Mars III: Strategies for exploration - General interest and overview. San Diego, CA, Univelt, Inc., 1989, p. 539-550. refs
(AAS PAPER 87-213) Copyright
An experimental program to investigate manufacturing processes and product qualities of duricretes, as well as composites

formed by combining such material with high-strength fibers (man-made and biogenic) has begun. Other source materials that may serve as components include various pigments, such as powdered C (black), MgO (white), and ferric oxide (red); binders and sealers, such as elemental and polymeric S; and metallic coatings and fibers, such as Mg. Carbon can be produced by the Bosch process for CO2 reduction to O2 and C; water distilled from indigenous ice; and the other products converted from MgSO4 in the soil salts. Applications of the construction materials include habitat enlargement, greenhouse fabrication, solar thermal absorption structures, storehouses/tanks, utensils, solar flare storm shelters, towers, and transportation construction. A Mars sample return mission will provide a more detailed understanding of the chemical properties of Martian soil, allowing better preparation of pilot study experiments for the first astronaut mission. Author

A90-16679
THE HYDROGEN PEROXIDE ECONOMY ON MARS
BENTON C. CLARK (Martin Marietta Planetary Sciences Laboratory, Denver, CO) and DONALD R. PETTIT (Los Alamos National Laboratory, NM) IN: The case for Mars III: Strategies for exploration - General interest and overview. San Diego, CA, Univelt, Inc., 1989, p. 551-557. refs
(AAS PAPER 87-214) Copyright

Hydrogen peroxide, H2O2, could serve as a multipurpose chemical storehouse of breathing oxygen, water, and energy for a Martian base. Made from indigenous water and electricity from a central power facility, it could function also as an energetic fluid to power mobile operations away from the base. Hydrogen peroxide is a monopropellant (as well as a bipropellant oxidizer) for rocket engines, a fuel for producing shaft work from turbines, and a high explosive that could find uses in construction, mining, and seismic studies. At the ambient conditions on Mars,it can be handled and stored not much differently than many hydrocarbon fuels are on earth. Hydrogen peroxide can serve many other useful functions such as an antifreeze solution in heat exchangers, a disinfectant, and a host of manufacturing applications in metallurgy, cements, and ceramics. H2O2 could well be the single most valuable commodity made on Mars, giving rise to a hydrogen peroxide economy. Author

31

ENGINEERING (GENERAL)

Includes vacuum technology; control engineering; display engineering; cryogenics; and fire prevention.

A90-16683
FIRE PROTECTION FOR A MARTIAN COLONY
ROBERT M. BEATTIE, JR. (Boeing Military Airplanes, Wichita, KS) IN: The case for Mars III: Strategies for exploration - General interest and overview. San Diego, CA, Univelt, Inc., 1989, p. 595-605. refs
(AAS PAPER 87-218) Copyright

The fire prevention failures that occurred in Apollo 1 and Challenger accidents are reviewed and used to discuss fire protection measures that should be taken in a Martian colony. Fire detection systems, classes of fire, and suppression agents are described. The organization of fire fighting personnel appropriate for Mars is addressed. C.D.

33

ELECTRONICS AND ELECTRICAL ENGINEERING

Includes test equipment and maintainability; components, e.g., tunnel diodes and transistors; microminiaturization; and integrated circuitry.

A91-27353* Duke Univ., Durham, NC.
A DEPLOYABLE HIGH TEMPERATURE SUPERCONDUCTING COIL (DHTSC) - A NOVEL CONCEPT FOR PRODUCING MAGNETIC SHIELDS AGAINST BOTH SOLAR FLARE AND GALACTIC RADIATION DURING MANNED INTERPLANETARY MISSIONS
F. HADLEY COCKS (Duke University, Durham, NC) British Interplanetary Society, Journal (ISSN 0007-084X), vol. 44, March 1991, p. 99-102. refs
(Contract NASW-4453)
Copyright

The discovery of materials which are superconducting above 100 K makes possible the use of superconducting coils deployed beyond the hull of an interplanetary spacecraft to produce a magnetic shield capable of giving protection not only against solar flare radiation, but also even against Galactic radiation. Such deployed coils can be of very large size and can thus achieve the great magnetic moments required using only relatively low currents. Deployable high-temperature-superconducting coil magnetic shields appear to offer very substantial reductions in mass and energy compared to other concepts and could readily provide the radiation protection needed for a Mars mission or space colonies. Author

N87-17795*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
ELECTRICAL POWER SYSTEMS FOR MARS
ROBERT J. GIUDICI *In its* Manned Mars Mission. Working Group Papers, V. 2, Sect. 5, App. p 873-887 May 1986
Avail: NTIS HC A24/MF A04 CSCL 09C

Electrical power system options for Mars Manned Modules and Mars Surface Bases were evaluated for both near-term and advanced performance potential. The power system options investigated for the Mission Modules include photovoltaics, solar thermal, nuclear reactor, and isotope power systems. Options discussed for Mars Bases include the above options with the addition of a brief discussion of open loop energy conversion of Mars resources, including utilization of wind, subsurface thermal gradients, and super oxides. Electrical power requirements for Mission Modules were estimated for three basic approaches: as a function of crew size; as a function of electric propulsion; and as a function of transmission of power from an orbiter to the surface of Mars via laser or radio frequency. Mars Base power requirements were assumed to be determined by production facilities that make resources available for follow-on missions leading to the establishment of a permanently manned Base. Requirements include the production of buffer gas and propellant production plants. Author

37

MECHANICAL ENGINEERING

Includes auxiliary systems (nonpower); machine elements and processes; and mechanical equipment.

N90-29069*# Texas Univ., Austin. Dept. of Computer Science.
SATELLITE-MAP POSITION ESTIMATION FOR THE MARS ROVER
AKIRA HAYASHI and THOMAS DEAN (Brown Univ., Providence,

RI.) *In* JPL, California Inst. of Tech., Proceedings of the NASA Conference on Space Telerobotics, Volume 2 p 275-282 31 Jan. 1989 Sponsored in part by ARPA
(Contract F49620-88-C-0132; NSF IRI-86-12644)
Avail: NTIS HC A17/MF A03 CSCL 13I

A method for locating the Mars rover using an elevation map generated from satellite data is described. In exploring its environment, the rover is assumed to generate a local rover-centered elevation map that can be used to extract information about the relative position and orientation of landmarks corresponding to local maxima. These landmarks are integrated into a stochastic map which is then matched with the satellite map to obtain an estimate of the robot's current location. The landmarks are not explicitly represented in the satellite map. The results of the matching algorithm correspond to a probabilistic assessment of whether or not the robot is located within a given region of the satellite map. By assigning a probabilistic interpretation to the information stored in the satellite map, researchers are able to provide a precise characterization of the results computed by the matching algorithm. Author

44

ENERGY PRODUCTION AND CONVERSION

Includes specific energy conversion systems, e.g., fuel cells; global sources of energy; geophysical conversion; and windpower.

N89-20545*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
MARS MANNED TRANSPORTATION VEHICLE
MARLA E. PEREZ-DAVIS and KARL A. FAYMON Jul. 1987 12 p Presented at the Case for Mars III, Boulder, CO, 18-22 Jul. 1987; sponsored in part by American Astronautical Society; Jet Propulsion Lab.; NASA, Ames Res. Ctr.; NASA, Johnson Space Ctr; NASA, Marshall Space Flight Ctr.; and The Planetary Society
(NASA-TM-101487; E-4627; NAS 1.15:101487) Avail: NTIS HC A03/MF A01 CSCL 13F

A viable power system technology for a surface transportation vehicle to explore the planet Mars is presented. A number of power traction systems were investigated, and it was found that a regenerative hydrogen-oxygen fuel cell appears to be attractive for a manned Mars rover application. Mission requirements were obtained from the Manned Mars Mission Working Group. Power systems weights, power, and reactants requirements were determined as a function of vehicle weights for vehicles weighing from 6,000 to 16,000 lb (2,722 to 7,257 kg), (Earth weight). The vehicle performance requirements were: velocity, 10 km/hr; range, 100 km; slope climbing capability, 30 deg uphill for 50 km; mission duration, 5 days; and crew, 5. Power requirements for the operation of scientific equipment and support system capabilities were also specified and included in this study. The concept developed here would also be applicable to a Lunar based vehicle for Lunar exploration. The reduced gravity on the Lunar surface, (over that on the Martian surface), would result in an increased range or capability over that of the Mars vehicle since many of the power and energy requirements for the vehicle are gravity dependent. Author

51

LIFE SCIENCES (GENERAL)

A84-39233
ECOLOGICAL PROBLEMS AND EXTENDED LIFE SUPPORT ON THE MARTIAN SURFACE
B. MAGUIRE, JR. (Texas, University, Austin, TX) IN: The case for Mars; Proceedings of the Conference, Boulder, CO, April 29-May 2, 1981. San Diego, CA, Univelt, Inc., 1984, p. 163-171. refs
(AAS PAPER 81-238) Copyright

Questions regarding the expansion of life from its planet of origin are considered, taking into account the colonization of Mars from earth. The advantages of Mars are related to the possession of gravity, and (apparently) the relatively ready availability of all the major and minor elements which take part in the functioning of biological ecosytstems. It is pointed out that in any human-supporting, extraterrestrial ecosystem, an essentially complete cycling of all of the important elements must occur unless supplies external to the community are (sufficiently) readily available. Attention is given to the results of laboratory work with some small but closed samples of agricultural ecosystems, the observed collapse of samples of ecosystems, the avoidance of the inclusion of plant disease organisms in a self-supporting closed ecosystem, and problems with respect to the microbial flora of self-sustaining extraterrestrial colonies. G.R.

A90-16532* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SPACE STATION ACCOMMODATION OF LIFE SCIENCES IN SUPPORT OF A MANNED MARS MISSION
BARRY D. MEREDITH, KELLI F. WILLSHIRE, JANE A. HAGAMAN (NASA, Langley Research Center, Hampton, VA), and RHEA M. SEDDON (NASA, Johnson Space Center, Houston, TX) IN: The case for Mars III: Strategies for exploration - Technical. San Diego, CA, Univelt, Inc., 1989, p. 95-106.
(AAS PAPER 87-233) Copyright

Results of a life science impact analysis for accommodation to the Space Station of a manned Mars mission are discussed. In addition to addressing such issues as on-orbit vehicle assembly and checkout, the study also assessed the impact of a life science research program on the station. A better understanding of the effects on the crew of long duration exposure to the hostile space environment and to develop controls for adverse effects was the objective. Elements and products of the life science accommodation include: the identification of critical research areas; the outline of a research program consistent with the mission timeframe; the quantification of resource requirements; the allocation of functions to station facilities; and a determination of the impact on the Space Station program and of the baseline configuration. Results indicate the need at the Space Station for two dedicated life science lab modules; a pocket lab to support a 4-meter centrifuge; a quarantine module for the Mars Sample Return Mission; 3.9 man-years of average crew time; and 20 kilowatts of electrical power. C.E.

A90-16657* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
***AN OVERVIEW OF* SELECTED BIOMEDICAL ASPECTS OF MARS MISSIONS**
JOHN BILLINGHAM (NASA, Ames Research Center, Moffett Field, CA) IN: The case for Mars III: Strategies for exploration - General interest and overview. San Diego, CA, Univelt, Inc., 1989, p. 157-169. refs
(AAS PAPER 87-189) Copyright

There are major unresolved questions about changes in physiology of the crews of future zero-gravity manned Mars mission vehicles. This paper summarizes the changes induced by long duration weightlessness in different body systems, and emphasizes

the need for further research into these changes using animal and human subjects in space and in ground-based simulations. If the changes are shown not to be acceptable, it will be necessary to provide artificial gravity for the crew. Artificial gravity itself produces some physiological problems, and these also require extensive study. Both lines of research must be pursued with some urgency so that the major decision to have or not to have artificial gravity can be made on the basis of adequate information. Author

52

AEROSPACE MEDICINE

Includes physiological factors; biological effects of radiation; and effects of weightlessness on man and animals.

A84-39234
THE MEDICAL ASPECTS OF A FLIGHT TO MARS
D. WOODARD and A. R. OBERG IN: The case for Mars; Proceedings of the Conference, Boulder, CO, April 29-May 2, 1981. San Diego, CA, Univelt, Inc., 1984, p. 173-180.
(AAS PAPER 81-239) Copyright

Perhaps the greatest problem concerning a manned flight to Mars is related to uncertainties regarding the effect of a number of flight-related factors on the physical health and well-being of the crew. Of particular importance appears the long duration of the flight, which is probably two and a half years. The flight would involve a long exposure to various forms of radiation. Other questions are related to the prospect of having to survive the debilitating effects of zero gravity, and the further complication of having to survive the g-forces of landings both on Mars and later again on earth. The medical problems of such a flight are considered, taking into account the overall response of the human body to a zero-gravity environment, health countermeasures to reduce the worst side-effects of long-term space flight, design factors which can avoid health problems, and the medical supplies and facilities which might be needed to maintain health during the flight. G.R.

A84-39235
MODIFICATIONS OF CONVENTIONAL MEDICAL-SURGICAL TECHNIQUES FOR USE IN NULL GRAVITY
R. M. BEATTIE, JR. IN: The case for Mars; Proceedings of the Conference, Boulder, CO, April 29-May 2, 1981. San Diego, CA, Univelt, Inc., 1984, p. 181-184. refs
(AAS PAPER 81-240) Copyright

The possibility is considered that during the mission at least one person of the crew will experience clinical death by cardio-pulmonary arrest. Microgravity-related physical conditions will make all human resuscitative effors difficult. It is, therefore, recommended that the crew have well rehearsed standing orders for methods of clinical resuscitation. A Ready Area is to be prepared with mechanical chest compression, intermittent positive pressure ventilatory, and appropriate emergency adjective resuscitative equipment. Attention is given to details concerning the standing orders, and the equipment needed for the Ready Area. G.R.

A90-16537
ASTRONAUT INTERDISCIPLINARY AND MEDICAL/DENTAL TRAINING FOR MANNED MARS MISSIONS
HAROLD E. FILBERT (Martin Marietta Corp., Denver, CO) and DONALD J. KLEIER (Colorado, University, Denver) IN: The case for Mars III: Strategies for exploration - Technical. San Diego, CA, Univelt, Inc., 1989, p. 161-170.
(AAS PAPER 87-238) Copyright

This paper presents a general discussion of the medical and dental needs of astronauts on a manned Mars mission and a study of tradeoffs in meeting those needs. The discussion is based on the concept of interdisciplinary astronaut training/skills for prolonged manned space missions. The authors focus on the advantages of at least two years of intensive training in general medical practice and dentistry, with emphasis on space medicine and remote practice skills for all astronauts assigned to the mission. Existing, federally-funded training programs and facilities to accomplish the task are cited. Author

A90-16658* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
ARTIFICIAL GRAVITY FOR LONG DURATION SPACEFLIGHT
MALCOLM M. COHEN (NASA, Ames Research Center, Moffett Field, CA) IN: The case for Mars III: Strategies for exploration - General interest and overview. San Diego, CA, Univelt, Inc., 1989, p. 171-178.
(AAS PAPER 87-190) Copyright

This paper reviews the fundamental physical properties of gravitational and centrifugal forces, describes the physiological changes that result from long-term exposure to the nearly gravity-free environment of space, and explores the nature of these changes. The paper then cites currently employed and advanced techniques that can be used to prevent some of these changes. Following this review, the paper examines the potential use of artificial gravity as the ultimate technique to maintain terrestrial levels of physiological functioning in space, and indicates some of the critical studies that must be conducted and some of the trade-offs that must be made before artificial gravity can intelligently be used for long duration spaceflight. Author

A91-14071#
RADIATION SHIELDING ESTIMATION FOR MANNED SPACE FLIGHT TO THE MARS
V. E. DUDKIN, E. E. KOVALEV, A. V. KOLOMENSKII, V. A. SAKOVICH (Institut Mediko-Biologicheskikh Problem, Moscow, USSR), V. F. SEMENOV (AN SSSR, Institut Vysokikh Temperatur, Moscow, USSR) et al. IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 4 p. refs
(IAF PAPER 90-544) Copyright

The problem of shielding the crew from radiation during Mars missions is studied. Radiation hazards caused by Galactic cosmic rays (GCR) and solar cosmic rays (SCR) are considered, and it is noted that a radiation-proof shelter can reduce the hazards associated with SCR, while the shielding from multicharged GCR ions may be required for a habitation section of the spacecraft. The pulse operation of a nuclear rocket engine may also require some additional shielding of the crew and liquid-hydrogen tanks against reactor radiation. It is pointed out that any long-term residence within the earth radiation belt can be avoided by using certain combinations of space flight conditions, while Martian mission conditions may be attained by solving the problem of optimal distribution of the mass components for shadow shielding of the reactor and for shielding of the radiation-proof shelter and habitation section. The lowest estimate of the spacecraft mass including the radiation-shielding mass is found to be 500-550 tons. V.T.

53

BEHAVIORAL SCIENCES

Includes psychological factors; individual and group behavior; crew training and evaluation; and psychiatric research.

A90-16659* Anacapa Sciences, Inc., Santa Barbara, CA.
HABITABILITY DURING LONG-DURATION SPACE MISSIONS - KEY ISSUES ASSOCIATED WITH A MISSION TO MARS
JACK STUSTER (Anacapa Sciences, Inc., Santa Barbara, CA) IN: The case for Mars III: Strategies for exploration - General interest and overview. San Diego, CA, Univelt, Inc., 1989, p. 181-191.

(Contract NAS2-11690)
(AAS PAPER 87-191) Copyright

Isolation and confinement conditions similar to those of a long-duration mission to Mars are examined, focusing on 14 behavioral issues with design implications. Consideration is given to sleep, clothing, exercise, medical support, personal hygiene, food preparation, group interaction, habitat aesthetics, outside communications, recreational opportunities, privacy, waste disposal, onboard training, and the microgravity environment. The results are used to develop operational requirements and habitability design guidelines for interplanetary spacecraft. R.B.

A90-16660
CREW SELECTION FOR A MARS EXPLORER MISSION
BENTON C. CLARK (Martin Marietta Planetary Sciences Laboratory, Denver, CO) IN: The case for Mars III: Strategies for exploration - General interest and overview. San Diego, CA, Univelt, Inc., 1989, p. 193-203.
(AAS PAPER 87-192) Copyright

Issues related to the selection of crew members for a manned mission to Mars are discussed. The crew skills and character needed for a Mars mission are outlined and six basic types of crewmember skills needed for a mission are outlined. Consideration is given to the age and characteristics of crewmembers, safety, privacy, communication, and the issue of mission nomenclature. R.B.

A90-16661* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
HUMAN ASPECTS OF MISSION SAFETY
MARY M. CONNORS (NASA, Ames Research Center, Moffett Field, CA) IN: The case for Mars III: Strategies for exploration - General interest and overview. San Diego, CA, Univelt, Inc., 1989, p. 205-213. refs
(AAS PAPER 87-193) Copyright

Recent discussions of psychology's involvement in spaceflight have emphasized its role in enhancing space living conditions and incresing crew productivity. While these goals are central to space missions, behavioral scientists should not lose sight of a more basic flight requirement - that of crew safety. This paper examines some of the processes employed in the American space program in support of crew safety and suggests that behavioral scientists could contribute to flight safety, both through these formal processes and through less formal methods. Various safety areas of relevance to behavioral scientists are discussed. Author

A91-10023#
ANTARCTIC ANALOGS OF HUMAN FACTORS ISSUES DURING LONG-DURATION SPACE MISSIONS
LARRY BELL (Houston, University, TX) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 7 p. refs
(AIAA PAPER 90-3564) Copyright

The Sasakawa International Center for Space Architecture (SICSA) has undertaken requirement definition and planning studies for an international research and technology testbed facility in Antarctica to support future space mission simulations. This paper discusses the relevance of such an antarctic facility as an analog for examining human factors issues and requirements for long-duration space missions. It also highlights applications, benefits and limitations of other analogs from which important human factors lessons may be learned. Author

A91-10091*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
LONG DURATION MISSION SUPPORT OPERATIONS CONCEPTS
T. W. EGGLESTON (NASA, Johnson Space Center, Houston, TX) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 8 p. refs
(AIAA PAPER 90-3682) Copyright

It is suggested that the system operations will be one of the most expensive parts of the Mars mission, and that, in order to reduce their cost, they should be considered during the conceptual phase of the Space Exploration Initiative (SEI) program. System operations of Space Station Freedom, Lunar outpost, and Mars Rover Sample Return are examined in order to develop a similar concept for the manned Mars mission. Factors that have to be taken into account include: (1) psychological stresses caused by long periods of isolation; (2) the effects of boredom; (3) the necessity of onboard training to maintain a high level of crew skills; and (4) the 40-min time delays between issuing and receiving a command, which make real-time flight control inoperative and require long-term decisions to be made by the ground support. B.P.

54

MAN/SYSTEM TECHNOLOGY AND LIFE SUPPORT

Includes human engineering; biotechnology; and space suits and protective clothing.

A84-39232* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
EXTENDED MISSION LIFE SUPPORT SYSTEMS
P. D. QUATTRONE (NASA, Ames Research Center, Moffett Field, CA) IN: The case for Mars; Proceedings of the Conference, Boulder, CO, April 29-May 2, 1981. San Diego, CA, Univelt, Inc., 1984, p. 131-162. refs
(AAS PAPER 81-237) Copyright

The life support systems employed in manned space missions have generally been based on the use of expendables, such as, for instance, liquid oxygen. For the conducted space missions, such systems have advantages related to volume, weight, and economy of power consumption. However, this situation will change in connection with Shuttle Orbiter missions of extended duration, permanent manned facilities in low-earth orbit, and ultimately manned planetary vehicles. A description is given of suitable regenerative life support systems for such extended manned space missions. Attention is given to advanced life support systems technology, air revitalization, CO2 reduction, oxygen generation, nitrogen generation, trace contaminant control, air revitalization system integration, control/monitor instrumentation, water reclamation, solid waste management, manned testing and life support integration, an enhanced duration orbiter, a space operations center, manned interplanetary life support systems, and future development requirements. G.R.

A84-39238* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
THE ATMOSPHERE OF MARS - RESOURCES FOR THE EXPLORATION AND SETTLEMENT OF MARS
T. R. MEYER (Boulder Center for Science and Policy, Boulder, CO) and C. P. MCKAY (NASA, Ames Research Center, Space Science Div., Moffett Field, CA) IN: The case for Mars; Proceedings of the Conference, Boulder, CO, April 29-May 2, 1981. San Diego, CA, Univelt, Inc., 1984, p. 209-232. refs
(AAS PAPER 81-244) Copyright

This paper describes methods of processing the Mars atmosphere to supply water, oxygen and buffer gas for a Mars base. Existing life support system technology is combined with innovative methods of water extraction, and buffer gas processing. The design may also be extended to incorporate an integrated greenhouse to supply food, oxygen and water recycling. It is found that the work required to supply one kilogram of an argon/nitrogen buffer gas is 9.4 kW-hr. To extract water from the dry Martian atmosphere can require up to 102.8 kW-hr per kilogram of water depending on the relative humidity of the air. Author

A90-16531* New York Univ., New York.
THE CASE FOR CELLULOSE PRODUCTION ON MARS

TYLER VOLK (New York University, NY) and JOHN D. RUMMEL (NASA, Life Sciences Div., Washington, DC) IN: The case for Mars III: Strategies for exploration - Technical. San Diego, CA, Univelt, Inc., 1989, p. 87-94. refs
(Contract NCA2-101)
(AAS PAPER 87-232) Copyright

From examining the consequences of not requiring that all wastes from life support be recycled back to the food plants, it is concluded that cellulose production on Mars could be an important input for many nonmetabolic material requirements on Mars. The fluxes of carbon in cellulose production would probably exceed those in food production, and therefore settlements on Mars could utilize cellulose farms in building a Mars infrastructure. Author

A90-16534
A ZERO-G CELSS/RECREATION FACILITY FOR AN EARTH/MARS CREW SHUTTLE
ALICE EICHOLD (California, University, Berkeley) IN: The case for Mars III: Strategies for exploration - Technical. San Diego, CA, Univelt, Inc., 1989, p. 129-138. refs
(AAS PAPER 87-235) Copyright

This paper presents a zero-gravity architectural design for a module on an earth/Mars crew shuttle. Although in the early stages of development and of uncertain immediate cost-effectiveness, Controlled Ecological Life Support (CELSS) promises the most synergetic long-term means for providing food, air and water as well as accommodating 'homesickness'. In this project, plant growth units have been combined with recreation facilities to ensure that humans have daily opportunities to view their gardens. Furthermore, human exercise contributes toward powering the mechanical systems for growing the plants. The solution was arrived at by the traditional architectural design process with an empirical emphasis. The solution consists of smaller volumes for exercise facilities and plant growth units contained within a large geometrical sphere. Moisture and heat-generating activities thus share facilities and favorable gas exchanges are exploited. Author

A90-16656 Life Systems, Inc., Cleveland, OH.
LIFE SUPPORT SYSTEM CONSIDERATIONS AND CHARACTERISTICS FOR A MANNED MARS MISSION
FEROLYN T. POWELL (Life Systems, Inc., Cleveland, OH) IN: The case for Mars III: Strategies for exploration - General interest and overview. San Diego, CA, Univelt, Inc., 1989, p. 135-155. Research supported by NASA and Life Systems, Inc. refs
(AAS PAPER 87-188) Copyright

Both the Low Earth Orbit (LEO) Space Station and future manned space missions require Environmental Control and Life Support Systems (ECLSS) that provide safe, comfortable environments in which humans can live and work. The ECLSS functions and requirements (performance and design load) for these missions are defined. Options for closing the ECLSS cycle are discussed and the level of closure planned for the initial orbital capability (IOC) Space Station are quantified. The impacts of the remaining ECLSS expendables on advanced missions are discussed. Also discussed are the new ECLSS requirements related to generation of food (via plants, animals and/or fish). The paper focuses on the ECLSS design drivers associated with a manned Mars mission. These drivers include environmental, operational and interface drivers. Characteristics of the IOC Space Station ECLSS are given to provide a quantitative feeling of the magnitude of the ECLSS for a Mars mission. Author

A90-49313* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
ACTIVE THERMAL CONTROL SYSTEMS FOR LUNAR AND MARTIAN EXPLORATION
MICHAEL K. EWERT, PATRICIA A. PETETE, and JOHN DZENITIS (NASA, Johnson Space Center, Houston, TX) SAE, Intersociety Conference on Environmental Systems, 20th, Williamsburg, VA, July 9-12, 1990. 13 p. refs
(SAE PAPER 901243) Copyright

Several ATCS options including heat pumps, radiator shading devices, and single-phase flow loops were considered. The ATCS chosen for both lunar and Martian habitats consists of a heat pump integral with a nontoxic fluid acquisition and transport loop, and vertically oriented modular reflux-boiler radiators. The heat pump operates only during the lunar day. The lunar and Martian transfer vehicles have an internal single-phase water-acquisition loop and an external two-phase ammonia rejection system with rotating inflatable radiators. The lunar and Martian excursion vehicles incorporate internal single-phase water acquisition, which is connected via heat exchangers to external body-mounted single-phase radiators. A water evaporation system is used for the transfer vehicles during periods of high heating. Author

A90-49430* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
A METHODOLOGY FOR CHOOSING CANDIDATE MATERIALS FOR THE FABRICATION OF PLANETARY SPACE SUIT STRUCTURES
GILDA JACOBS (NASA, Ames Research Center; Sterling Software, Inc., Moffett Field, CA) SAE, Intersociety Conference on Environmental Systems, 20th, Williamsburg, VA, July 9-12, 1990. 9 p. refs
(SAE PAPER 901429) Copyright

A study of space suit structures and materials is under way at NASA Ames Research Center, Moffett Field, CA. The study was initiated by the need for a generation of lightweight space suits to be used in future planetary Exploration Missions. This paper provides a brief description of the Lunar and Mars environments and reviews what has been done in the past in the design and development of fabric, metal, and composite suit components in order to establish criteria for comparison of promising candidate materials and space suit structures. Environmental factors and mission scenarios will present challenging material and structural requirements; thus, a program is planned to outline the methodology used to identify materials and processes for producing candidate space suit structures which meet those requirements. Author

A91-10159#
ADVANCED EXTRAVEHICULAR ACTIVITY REQUIREMENTS IN SUPPORT OF THE MANNED MARS MISSION
WILLIAM R. POGUE, GERALD P. CARR (CAMUS, Inc., Huntsville, AL), and NICHOLAS SHIELDS, JR. (RECCEN Corp., Huntsville, AL) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 8 p. refs
(AIAA PAPER 90-3801) Copyright

The support requirements for an extended human exploration of the Martian surface by a crew of eight are examined. Emphasis is given to EVA activities at the base camp and to extended EVA and the environmental conditions impacting on the latter. The roles of hardware and machine system requirements in EVA are addresed. C.D.

A91-12594* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
CREW SUPPORT FOR AN INITIAL MARS EXPEDITION
YVONNE A. CLEARWATER (NASA, Ames Research Center, Moffett Field, CA) and ALBERT A. HARRISON (California, University, Davis) British Interplanetary Society, Journal (ISSN 0007-084X), vol. 43, Nov. 1990, p. 513-518. refs
Copyright

Mars crews will undergo prolonged periods of isolation and confinement, travel unprecedented distances from earth and be subjected to formidable combinations of hardships and dangers. Some of the biomedical, psychological and social challenges of the first manned Mars expedition are reviewed and means of aligning humans, technology and space habitats in the interests of mission success are identified. Author

A91-14737* National Aeronautics and Space Administration, Washington, DC.
CONTROLLED ECOLOGICAL LIFE SUPPORT SYSTEM
MAURICE M. AVERNER (NASA, Washington, DC) IN: Lunar base agriculture: Soils for plant growth. Madison, WI, American Society of Agronomy, Inc., Crop Science Society of America, Inc.,

and Soil Science Society of America, Inc., 1989, p. 145-153. refs

The NASA CELLS program is based upon the integration of biological and physiochemical processes in order to produce a system that will produce food, a breathable atmosphere, and potable water from metabolic and other wastes. The CELSS concept is described and a schematic system diagram is provided. Central to the CELSS concept is the Plant Growth Chamber, where green plant photosynthesis produces food, and aids in the production of oxygen and water. Progress to date at the Breadboard Facility at the Kennedy Space Center is summarized. The Breadboard Facility will implement the basic techniques and processes required for a CELSS based on photosynthetic plant growth in a ground-based system of practical size and results will be extrapolated to predict the performance of a full-sized system. Current available technology and near-future forecasts for plant growth techniques (focusing on maximum productivity), food sources (to select optimal CELSS plants), and waste management and contaminant control are discussed. L.K.S.

A91-14738* National Aeronautics and Space Administration. John F. Kennedy Space Center, Cocoa Beach, FL.
CELSS BREADBOARD PROJECT AT THE KENNEDY SPACE CENTER
R. P. PRINCE and W. M. KNOTT, III (NASA, Kennedy Space Center, Cocoa Beach, FL) IN: Lunar base agriculture: Soils for plant growth. Madison, WI, American Society of Agronomy, Inc., Crop Science Society of America, Inc., and Soil Science Society of America, Inc., 1989, p. 155-163. refs

The CELSS Breadboard Project is described, noting that it was initiated to study aspects of a CELSS for long-term space missions. Topics for extensive investigation included air and water regeneration, engineering control, and food production. The many options available for growing food crops in commercial plant growth chambers were investigated and the best of this information was translated to the Biomass Production Chamber (BPC). The chamber contains 20 sq m of crop growing area under 96 400 W HPS lamps; sixteen 0.25 sq m plant growth trays used on each of four growing shelves for a total of 64 trays; and one 256-L nutrient solution reservoir with the appropriate continuous-flow, thin-film plumbing for each shelf. A heating, ventilating, and air-conditioning system maintains atmospheric conditions and serves to distribute oxygen and carbon dioxide and maintain pressure at 12 mm of water. The control and monitoring subsystem, which uses a programmable logic controller, manages the BPC subsystems. L.K.S.

A91-23461
BIOGENERATIVE LIFE-SUPPORT SYSTEM - FARMING ON THE MOON
FRANK B. SALISBURY (Utah State University, Logan) (IAA, IAF, AN SSSR, et al., Symposium on Man in Space, 8th, Tashkent, Uzbek SSR, Sept. 29-Oct. 3, 1990) Acta Astronautica (ISSN 0094-5765), vol. 23, 1991, p. 263-270. refs

Plants can be used to recycle food, oxygen, and water in a closed habitat on the moon, on Mars, or in a spacecraft. A variety of crops might be grown, probably in underground growth units to avoid harmful radiation and micrometeorites. Artificial light will be necessary, although some sunlight might be brought in via fiber optics. Transpired water will be condensed in coils exposed to space and shaded from sunlight. Oxygen and CO2 levels will be maintained by controlling photosynthesis and waste oxidation. Plants will be grown hydroponically. Wheat has been produced at the rate of 60 g/sq m per day, which could feed a human continuously from a farm only of 13 sq m, but nearly continuous light equivalent to sunlight is required along with ideal temperatures, enriched CO2, suitable cultivars, etc. Author

A91-23462
REGENERATIVE LIFE-SUPPORT SYSTEM DEVELOPMENT PROBLEMS FOR THE MARS MISSION
V. N. KUBASOV, E. N. ZAITSEV, V. A. KORSAKOV, A. S. GUZENBERG, and A. A. LEPSKII (NPO Energiia, Moscow, USSR) (IAA, IAF, AN SSSR, et al., Symposium on Man in Space, 8th, Tashkent, Uzbek SSR, Sept. 29-Oct. 3, 1990) Acta Astronautica (ISSN 0094-5765), vol. 23, 1991, p. 271-274.

The advantages and disadvantages of physiochemical and biotechnological complexes of life support systems are discussed. These systems are each analyzed on the basis of technological, economic, and biomedical parameters. The complex of technological and economic parameters includes the mass, power consumption, reliability, maintainability, and crew labor outlay both in the initial condition and under operating conditions. The most likely trends of manned cosmonautics development for the nearest decades are discussed. Analysis results show that the physiochemical complex is more advantageous than the biotechnological one for all cases considered. This conclusion is based on significant differences in energy utilization factors: 70-90 percent for the PhChLSS and 5-10 percent for the BLSS. System selection is also discussed. L.K.S.

A91-23463
PROVIDING A SOUND HABITAT FOR MAN IN SPACE
MARIA STRANGER-JOHANNESSEN (Centre for Industrial Research, Oslo, Norway) (IAA, IAF, AN SSSR, et al., Symposium on Man in Space, 8th, Tashkent, Uzbek SSR, Sept. 29-Oct. 3, 1990) Acta Astronautica (ISSN 0094-5765), vol. 23, 1991, p. 275-277. refs

The problem of microbial growth on materials in a closed environment is discussed, drawing inferences from analogous situations which occur in new buildings which are more tightly sealed and widely employ air conditioning. It is noted that the 'sick building syndrome' has contributed to serious problems such as legionnaire's disease and that the potential of such microbiological hazards must be researched and guarded against in long-term space habitats. ESA has begun work on microbial contamination control measures and requirements. Procedures are being established as a basis for the microbiological cleanliness of the manned space environment and for the avoidance of microbiological growth on materials and equipment. Several testing techniques are being studied which will allow both a rapid screening of materials' resistance to microbiological growth and proper durability testing of materials and equipment to be used for up to 30 years in space habitats. L.K.S.

A91-23464
MANNED EXPEDITION TO MARS - CONCEPTS AND PROBLEMS
LIUBOV' B. STROGONOVA (Institut Mediko-Biologicheskikh Problem, Moscow, USSR) and LEONID GORSHKOV (NPO Energiia, Moscow, USSR) (IAA, IAF, AN SSSR, et al., Symposium on Man in Space, 8th, Tashkent, Uzbek SSR, Sept. 29-Oct. 3, 1990) Acta Astronautica (ISSN 0094-5765), vol. 23, 1991, p. 279-287.

The concept of long-term interplanetary flight is discussed, and some main criteria for interplanetary spacecraft are presented. The present state of space technology for interplanetary spacecraft is considered, and it is argued that the knowledge accumulated at present by cosmonauts is sufficient to begin preparation for a manned flight to Mars. An eight-stage program for such a flight, which is projected to have a duration of two years, is presented. The biomedical aspects of long-term interplanetary flight and the complications arising due to lack of technical supply for the solution of such problems are considered. The questions of the biological security of the earth after the planetary flight and of international cooperation in interplanetary expeditions are also addressed. L.K.S.

N90-26499*# Wisconsin Univ., Milwaukee. Space Architecture Design Group.
GENESIS LUNAR OUTPOST CRITERIA AND DESIGN
TIMOTHY HANSMANN, ed. & comp., GARY T. MOORE, ed. & comp., DINO J. BASCHIERA, JOE PAUL FIEBER, and JANIS HUEBNER MOTHS 11 Jun. 1990 119 p
(Contract NASW-4435)
(NASA-CR-186831; NAS 1.26:186831; R90-1;
ISBN-0-938744-69-0) Avail: NTIS HC A06/MF A01 CSCL 05H

This design study--the third in the space architecture series--focused on the requirements of an early stage lunar outpost. The driving assumptions of the scenario was that the base would serve as a research facility and technology testbed for future Mars missions, a habitat supporting 12 persons for durations of up to 20 months, and would sustain the following five experimental facilities: Lunar surface mining and production analysis facility, construction technology and materials testbed, closed environmental life support system (CELSS) test facility, lunar farside observatory, and human factors and environment-behavior research facility. Based upon the criteria set forth in a previous programming document, three preliminary lunar base designs were developed. Each of the three schemes studied a different construction method and configuration. The designs were then evaluated in terms of environmental response, human habitability, transportability, constructability, construction dependability and resilience, and their suitability in carrying out the desired scientific research. The positive points of each scheme were then further developed by the entire project team, resulting in one integrated lunar outpost design.
Author

N91-16570# Messerschmitt-Boelkow-Blohm G.m.b.H., Bremen (Germany, F.R.).
COMMON APPROACH FOR PLANETARY HABITATION SYSTEMS IMPLEMENTATION
FRANK STEINSIEK and UWE APEL 1990 11 p Presented at the 20th International Conference on Environmental Systems, Williamsburg, VA, 9-12 Jul. 1990 Previously announced in IAA as A90-49425 Prepared in cooperation with Erno Raumfahrttechnik G.m.b.H.
(MBB-UO-0115-90-PUB; ETN-91-98549) Avail: NTIS HC/MF A03

Possible concepts for orbital, lunar and Martian habitations are based on ESA-European Manned Space Infrastucture (EMSI) program philosophy are presented. The key requirements for the design of an orbital habitat were reviewed, such as atmospheric pressure, temperature, radiation and gravity levels. The human factors such as life cycle, ergonomy and psychological needs were examined. A common approach for these three cases may be to use as much available hardware in each step of the scenario as possible. The implementation of the habitation systems offers the possibility to work in an evolutionary way, starting with the EMSI Columbus based hardware.
ESA

55

SPACE BIOLOGY

Includes exobiology; planetary biology; and extraterrestrial life.

A89-51522* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
STABLE CARBON ISOTOPE FRACTIONATION IN THE SEARCH FOR LIFE ON EARLY MARS
L. J. ROTHSCHILD and D. DESMARAIS (NASA, Ames Research Center, Moffett Field, CA) (COSPAR, Plenary Meeting, 27th, Topical Meeting and Workshops on the Life Sciences and Space Research XXIII(2): Planetary Biology and Origins of Life, 20th, 21st, and 23rd, Espoo, Finland, July 18-29, 1988) Advances in Space Research (ISSN 0273-1177), vol. 9, no. 6, 1989, p. 159-165. refs
Copyright

The utility of measurements of C-13/C-12 ratios in organic vs inorganic deposits for searching for signs of life on early Mars is considered. It is suggested that three assumptions are necessary. First, if there was life on Mars, it caused the fractionation of carbon isotopes in analogy with past biological activity on earth. Second, the fractionation would be detectable. Third, if a fractionation would be observed, there exist no abiotic explanations for the observed fractionation pattern.
I.S.

A89-51523* Florida State Univ., Tallahassee.
LIFE ON MARS - HOW IT DISAPPEARED (IF IT WAS EVER THERE)
E. IMRE FRIEDMANN and ALI M. KORIEM (Florida State University, Tallahassee) (COSPAR, Plenary Meeting, 27th, Topical Meeting and Workshops on the Life Sciences and Space Research XXIII(2): Planetary Biology and Origins of Life, 20th, 21st, and 23rd, Espoo, Finland, July 18-29, 1988) Advances in Space Research (ISSN 0273-1177), vol. 9, no. 6, 1989, p. 167-172. refs
(Contract NSG-7337; NSF DPP-83-14180)
Copyright

Information available on Mars chemistry suggest that conditions on early Mars may have been suitable for life. This paper examines the possible events that led to the disappearance of life, assuming it existed, from the surface of Mars. The sequence of events leading to life extinction on early Mars assumes the following steps: (1) a decrease of temperature and humidity levels, leading to a selection of microorganisms for tolerance of low temperatures and arid conditions; (2) further deterioration of environment leading to withdrawal of cold-adapted organisms to protected niches under the surface; (3) further cooling producing heavy stresses in these organisms; and (4) further deterioration of the environment resulting in extinction. This sequence of events is considered parallel events documented for the microbial community in the Ross Desert of Antarctica, where TEM examinations of the material detected progressive stages of cell damage and death.
I.S.

A89-51527* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
PEROXIDES AND THE SURVIVABILITY OF MICROORGANISMS ON THE SURFACE OF MARS
ROCCO L. MANCINELLI (NASA, Ames Research Center, Moffett Field, CA) (COSPAR, Plenary Meeting, 27th, Topical Meeting and Workshops on the Life Sciences and Space Research XXIII(2): Planetary Biology and Origins of Life, 20th, 21st, and 23rd, Espoo, Finland, July 18-29, 1988) Advances in Space Research (ISSN 0273-1177), vol. 9, no. 6, 1989, p. 191-195. refs
Copyright

This paper discusses the possibility that any terrestrial microorganisms brought to Mars might survive the unhospitable environment of that planet, with special attention given to the effects of highly oxidizing material that is now known to cover the Martian surface. Data obtained by the gas exchange experiment on Viking indicate that, if all of the released oxygen is assumed to come from H2O2, the concentrations of H2O2 on Mars range from 25 to 250 ppm. Laboratory data indicate that certain soil bacteria are able to survive and grow to stationary phase at H2O2 concentrations as high as 30,000, indicating that, if there is H2O2 at the level of 250 ppm or even an order of magnitude greater on the Martian surface, this fact alone would not make the surface of Mars self-sterilizing.
I.S.

A89-51528* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
PLANETARY PROTECTION ISSUES IN ADVANCE OF HUMAN EXPLORATION OF MARS
CHRISTOPHER P. MCKAY (NASA, Ames Research Center, Moffett Field, CA) and WANDA L. DAVIS (Search for Extraterrestrial Intelligence Institute, Los Altos, CA) (COSPAR, Plenary Meeting, 27th, Topical Meeting and Workshops on the Life Sciences and Space Research XXIII(2): Planetary Biology and Origins of Life, 20th, 21st, and 23rd, Espoo, Finland, July 18-29, 1988) Advances

in Space Research (ISSN 0273-1177), vol. 9, no. 6, 1989, p. 197-202. refs
Copyright

The major planetary quarantine issues associated with human exploration of Mars, which is viewed as being more likely to harbor indigenous life than is the moon, are discussed. Special attention is given to the environmental impact of human missions to Mars due to contamination and mechanical disturbances of the local environment, the contamination issues associated with the return of humans, and the planetary quarantine strategy for a human base. It is emphasized that, in addition to the question of indigenous life, there may be some concern of returning to earth the earth microorganisms that have spent some time in the Martian environment. It is suggested that, due to the fact that a robot system can be subjected to more stringent controls and protective treatments than a mission involving humans, a robotic sample return mission can help to eliminate many planetary-quarantine concerns about returning samples. I.S.

80

SOCIAL SCIENCES (GENERAL)

Includes educational matters.

A90-13598#
TOGETHER TO MARS - AN INTERNATIONAL STUDENT CONTEST CULMINATING IN THE INTERNATIONAL SPACE YEAR
LOUIS FRIEDMAN and TIMOTHY LYNCH (Planetary Society, Pasadena, CA) IAF, International Astronautical Congress, 40th, Malaga, Spain, Oct. 7-13, 1989. 6 p.
(IAF PAPER 89-543) Copyright

Plans are presented for an international student contest on the human exploration of Mars to be conducted in the International Space Year, 1992. The rules of the contest, plans for awards, and types of entries that may be submitted to the contest are considered. Possible topics for the contest are presented, focusing on the theme of life support for humans for flight to and from and exploring Mars. R.B.

A90-16654* National Aeronautics and Space Administration, Washington, DC.
A MANDATE FOR SPACE EDUCATION
JESCO VON PUTTKAMER (NASA, Office of Space Flight, Washington, DC) IN: The case for Mars III: Strategies for exploration - General interest and overview. San Diego, CA, Univelt, Inc., 1989, p. 57-72.
(AAS PAPER 87-182) Copyright

Issues related to public education in preparation for a manned Mars program are discussed. Consideration is given to the near- and long-term goals of the space program, the benefits of human expansion in space, and long-range planning for fundamental problem areas in space education. Important concerns for space educators are outlined. R.B.

81

ADMINISTRATION AND MANAGEMENT

Includes management planning and research.

A91-24875*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
QUALITY ASSURANCE PLANNING FOR LUNAR MARS EXPLORATION
KAY MYERS (NASA, Johnson Space Center; Barrios Technology, Inc., Houston, TX) Total Quality Management Conference, Palm Springs, CA, Feb. 7, 8, 1991, Paper. 7 p.

A review is presented of the tools and techniques required to meet the challenge of total quality in the goal of traveling to Mars and returning to the moon. One program used by NASA to ensure the integrity of baselined requirements documents is configuration management (CM). CM is defined as an integrated management process that documents and identifies the functional and physical characteristics of a facility's systems, structures, computer software, and components. It also ensures that changes to these characteristics are properly assessed, developed, approved, implemented, verified, recorded, and incorporated into the facility's documentation. Three principal areas are discussed that will realize significant efficiencies and enhanced effectiveness, change assessment, change avoidance, and requirements management. R.E.P.

83

ECONOMICS AND COST ANALYSIS

Includes cost effectiveness studies.

A84-39243* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
THE COST OF LANDING MAN ON MARS
H. C. MANDELL, JR. (NASA, Johnson Space Center, Houston, TX) IN: The case for Mars; Proceedings of the Conference, Boulder, CO, April 29-May 2, 1981. San Diego, CA, Univelt, Inc., 1984, p. 281-292.
(AAS PAPER 81-251) Copyright

In a period where the space program budget is generally static at about 1/3 of the level reached during the Apollo program, manned planetary flight is not considered by NASA planners to be a realistic near term goal. Much of NASA's current planning is based on the perception that manned planetary flight would be more costly than the Apollo lunar landing. This paper demonstrates that with current technological improvements in avionics, structure, and space transportation, the landing of an American on Mars would cost only 1/3 to 2/3 of the lunar landing; on a per capita basis such a program would cost less than $200, compared to Apollo's $325 (all dollars in 1981 base). Given the fact that a manned Mars landing is the last such exploration feat left to this generation, the cost should clearly not be a major deterrent. Author

A90-16655
FINANCING A MARS PROGRAM
CHANDLER C. SMITH (Ball Corp., Ball Aerospace Systems Group, Boulder, CO) IN: The case for Mars III: Strategies for exploration - General interest and overview. San Diego, CA, Univelt, Inc., 1989, p. 83-106. refs
(AAS PAPER 87-184) Copyright

The prospects for financing a Mars program are evaluated, including estimates of the approximate amount of money required to implement a program. The financial issues related to other large-scale efforts, such as the Apollo program, the Manhattan project, and the Tennessee Valley Authority are reviewed and compared with the financing of a Mars program. Consideration is given to economic base forecasts, government spending predictions, the impact of an aging population, and the possibility of nontraditional sources of revenue for a Mars program. R.B.

A91-14089#
WHAT IS THE COST OF SEI? AN APPROACH TO ESTIMATING THE LIFE CYCLE COST OF THE SPACE EXPLORATION INITIATIVE
RICHARD L. WEBB (General Dynamics Corp., Space Systems Div., San Diego, CA) IAF, International Astronautical Congress,

41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 12 p. refs
(IAF PAPER 90-601) Copyright

The paper presents an approach for estimating the Life Cycle Cost (LCC) of four alternative Space Exploration Initiative (SEI) program scenarios. SEI philosophy and goals are considered of primary importance in the cost estimation of the program. The following primary issues have been identified: the cost of system unreliability, the cost and benefits of international participation, methods for estimating 'new ways of doing business', quantification of cost risk, cost as a measure of milestone achievement, and 'affordability.' It is pointed out that the possibilities for international participation present a significant challenge in the cost estimating of SEI with respect to divisions of responsibility, management organization, integration activities, and variations in currencies. B.P.

N87-17800*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
MANNED MARS MISSION COST ESTIMATE
JOSEPH HAMAKER and KEITH SMITH *In its* Manned Mars Mission. Working Group Papers, V. 2, Sect. 5, App. p 936-950 May 1986
Avail: NTIS HC A24/MF A04 CSCL 05C

The potential costs of several options of a manned Mars mission are examined. A cost estimating methodology based primarily on existing Marshall Space Flight Center (MSFC) parametric cost models is summarized. These models include the MSFC Space Station Cost Model and the MSFC Launch Vehicle Cost Model as well as other modes and techniques. The ground rules and assumptions of the cost estimating methodology are discussed and cost estimates presented for six potential mission options which were studied. The estimated manned Mars mission costs are compared to the cost of the somewhat analogous Apollo Program cost after normalizing the Apollo cost to the environment and ground rules of the manned Mars missions. It is concluded that a manned Mars mission, as currently defined, could be accomplished for under $30 billion in 1985 dollars excluding launch vehicle development and mission operations. Author

84

LAW, POLITICAL SCIENCE AND SPACE POLICY

Includes NASA appropriation hearings; aviation law; space law and policy; international law; international cooperation; and patent policy.

A84-39241
LEGAL AND POLITICAL IMPLICATIONS OF COLONIZING MARS
N. C. GOLDMAN (Texas, University, Austin, TX) IN: The case for Mars; Proceedings of the Conference, Boulder, CO, April 29-May 2, 1981. San Diego, CA, Univelt, Inc., 1984, p. 257-262. refs
(AAS PAPER 81-248) Copyright

The effects of international space law, including four treaties and the proposed 'Moon' treaty, on the future of Mars are discussed. The decision to go will be made by a government or consortium of governments, since treaty law inhibits private enterprise in space and a mission to Mars would be extremely expensive. Since the surface of Mars cannot be claimed by any nation, any colony created there would have to be open to inspection by representatives of other nations after giving reasonable advance notice. Nations would, however, own the structures that they erect on Mars. The treaty law governing the mining of ore on celestial bodies is ambiguous. Natural resources existing on Mars would not be the property of any state until mined under licence from some supranational authority. C.D.

A89-12542
LET'S GO TO MARS TOGETHER
JOHN L. MCLUCAS and BURTON I. EDELSON Issues in Science and Technology (ISSN 0748-5492), vol. 5, Fall 1988, p. 52-55. refs
Copyright

Arguments for cooperative U.S.-Soviet missions to Mars are presented. The history of space competition since the 1950s is briefly recalled; the current status is surveyed; and Soviet plans for Martian missions (including the Phobos probe launched in July 1988, a heavy automated Mars lander with robotic rover for 1994, a sample-return mission for 1996-1998, and eventual manned missions) are described and contrasted with NASA planning, where the Mars Observer (1992) is the only firm program, although Mars exploration has been established as a policy goal. Concrete steps toward joint or international Mars missions are proposed, building on the 1986 U.S.-Soviet cooperative agreement (which includes four Mars-related projects): (1) defining a general concept of cooperation, (2) setting robotic exploration in the 1990s and manned exploration in the next century as primary goals, and (3) convening a joint planning team to assign tasks and set schedules in detail. T.K.

88

SPACE SCIENCES (GENERAL)

A91-25834
WIND, SAND, AND MARS - THE 1990 TESTS OF THE MARS BALLOON AND SNAKE
CHARLENE M. ANDERSON (Planetary Society, Pasadena, CA) Planetary Report (ISSN 0736-3680), vol. 11, Jan.-Feb. 1991, p. 12-15.
Copyright

The observations of one member of the international team of Planetary Society members responsible for testing the Mars balloon and SNAKE are presented. The tests were held in the fall of 1990 in Indio, California, and concluded successfully. The test team was made up of scientists and technicians from CNES; observers from the Babakin Center; scientists from the Space Research Institute of the Soviet Academy of Sciences; engineers from the Jet Propulsion Laboratory; students from the University of Arizona, Utah State University, UCLA, and Caltech; and Planetary Society volunteers. The chosen sites of study in this desert area were selected to simulate as neary as possible Mars-like conditions and included smooth ancient lake beds, jagged frozen lava flows and gently rolling sand dunes. L.K.S.

91

LUNAR AND PLANETARY EXPLORATION

Includes planetology; and manned and unmanned flights.

A84-39226
THE CASE FOR MARS; PROCEEDINGS OF THE CONFERENCE, UNIVERSITY OF COLORADO, BOULDER, CO, APRIL 29-MAY 2, 1981
P. J. BOSTON, ED. (National Center for Atmospheric Research, Boulder, CO) Conference sponsored by the University of Colorado, Boulder Center for Science and Policy, American Institute of Aeronautics and Astronautics, et al. San Diego, CA, Univelt, Inc., 1984, 347 p.
Copyright

The subjects investigated are related to mission strategy,

spacecraft design, life support, surface activities and materials processing, and social and political aspects. The humanation of Mars is discussed along with reasons for considering Mars as an object for human exploration, the Viking fund, ballistic opportunities to Mars, a short guide to Mars, and the future of Mars. Attention is given to new approaches to space exploration, a manned mission to Phobos and Deimos, manned Mars mission landing and departure systems, the solar electric propulsion stage as a Mars exploration tool, modifications of conventional medical-surgical techniques for use in null gravity, surface sampling systems, a retrospective look at the Soviet Union's efforts to explore Mars, the cost of landing man on Mars, the atmosphere of Mars, and the utilization of the Shuttle external tank for earth to Mars transit. G.R.

A84-39227
THE HUMANATION OF MARS
L. W. DAVID (National Space Institute, Washington, DC) IN: The case for Mars; Proceedings of the Conference, Boulder, CO, April 29-May 2, 1981. San Diego, CA, Univelt, Inc., 1984, p. 3-17. refs
(AAS PAPER 81-227) Copyright

Early developments related to human excursions to Mars are examined, taking into account plans considered by von Braun, and the 'ambitious goal of a manned flight to Mars by the end of the century', proposed at the launch of Apollo 11. In response to public reaction, plans for manned flights to Mars in the immediate future were given up, and unmanned reconnaissance of Mars was continued. An investigation is conducted concerning the advantages of manned exploration of Mars in comparison to a study by unmanned space probes, and arguments regarding a justification for interplanetary flight to Mars are discussed. Attention is given to the possibility to consider Mars as a 'back-up' planet for preserving earth life, an international Mars expedition as a world peace project, the role of Mars in connection with resource utilization considerations, and questions of exploration ethics. G.R.

A84-39228*
THE PH-D PROPOSAL - A MANNED MISSION TO PHOBOS AND DEIMOS
S. F. SINGER IN: The case for Mars; Proceedings of the Conference, Boulder, CO, April 29-May 2, 1981. San Diego, CA, Univelt, Inc., 1984, p. 39-65.
(Contract NASA ORDER H-27272-B; NASA ORDER H-343115-B)
(AAS PAPER 81-231) Copyright

The rationale for a manned mission to the satellites of Mars is discussed. The view has been expressed that NASA must define a major program to follow the Shuttle and to utilize it. However, such a program could not be initiated and proceed without public support, and to obtain this support, public interest would have to be excited. It is shown that, of a number of possible targets for manned exploration in the solar system, Mars appears to be the only possible candidate. Attention is given to a comparison of three Mars missions, a Mars 1984 mission, a manned landing on Mars surface, a manned landing on Phobos and Deimos (Ph-D project), putting men in Mars orbit, the capabilities of the Ph-D mission, a description of the spacecraft, a Ph-D project operations plan, and aspects of timing, technology, and costs. G.R.

A84-39236
MANNED EXPLORATION OF MARS - THE ROLE OF SCIENCE
J. A. CUTTS IN: The case for Mars; Proceedings of the Conference, Boulder, CO, April 29-May 2, 1981. San Diego, CA, Univelt, Inc., 1984, p. 191-196.
(AAS PAPER 81-242) Copyright

It is pointed out that the unmanned exploration of Mars motivated purely by science is essentially over. However, the rebirth of a Mars program in a new form is expected to occur within a few years. This paper is concerned with the history of the Mars program, the benefits to be derived by science from the new program, and the role of unmanned precursor vehicles in manned exploration and settlement. The role of man in scientific exploration of Mars is examined, taking into account scientific objectives at Mars, the methods of investigation, requirements of surface mobility, the role of in situ science vs sample return, the need for precursor orbiter, and research needs. The case for a manned presence on Mars is briefly considered. G.R.

A84-39237
CHEMISTRY OF THE MARTIAN SURFACE - RESOURCES FOR THE MANNED EXPLORATION OF MARS
B. C. CLARK (Martin Marietta Planetary Sciences Laboratory, Denver, CO) IN: The case for Mars; Proceedings of the Conference, Boulder, CO, April 29-May 2, 1981. San Diego, CA, Univelt, Inc., 1984, p. 197-208. refs
(AAS PAPER 81-243) Copyright

It is pointed out that Mars is a bonanza in useable natural resources, while the moon is impoverished. For this reason, on Mars, many materials and equipment will be more economically manufactured on site than transported from earth. A survey of natural resources is conducted, taking into account water, carbon atoms, oxygen atoms, nitrogen atoms, phosphorus atoms, sulfur and chlorine atoms, mineral concentrates, and heavy elements. Questions regarding the processing of raw materials are discussed. Problems of purification are examined along with suitable approaches to manufacturing, and the employment of solar irradiance, geothermal heat, nuclear fission reactors, and wind power as energy sources. The utilization of the obtained products is also considered, giving attention to construction, construction materials, the need for blasting explosives, approaches for producing rocket fuel and rover fuel, and the growing of food on Mars. G.R.

A84-39242
A RETROSPECTIVE LOOK AT THE SOVIET UNION'S EFFORTS TO EXPLORE MARS
S. B. KRAMER (U.S. Department of Energy, Washington, DC) IN: The case for Mars; Proceedings of the Conference, Boulder, CO, April 29-May 2, 1981. San Diego, CA, Univelt, Inc., 1984, p. 269-279. refs
(AAS PAPER 81-250) Copyright

The history of USSR missions to Mars is reviewed on the basis of published reports and analysis of Soviet press accounts. The fourteen launches of the period 1960-1973 which were intended to reach Mars orbit, impact, or flyby are examined individually, and the basic parameters are listed in a table. Despite some partial successes, the overall program is considered to have given very meager results for its costs, which are estimated at over $4 billion. T.K.

A85-37171
MARS - PATHWAY TO THE STARS
J. A. ANGELO, JR. (Florida Institute of Technology, Melbourne, FL) and D. BUDEN (Los Alamos National Laboratory, Los Alamos, NM) IN: New opportunities in space; Proceedings of the Twenty-first Space Congress, Cocoa Beach, FL, April 24-26, 1984. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1984, p. 7-89 to 7-106. refs
Copyright

Mars has and will continue to play a key role in our exploration and conquest of the Solar System. Within the context of the creation of humanity's extraterrestrial civilization, the major technical features of the following Mars programs are reviewed: the Mars Geoscience/Climatology Orbiter; the Mars Aeronomy Orbiter; the Mars airplane; the Mars Penetrator Network; Mars surface rovers and mobility systems; human exploration of Mars; and permanent Martian bases and settlements. Mars properly explored and utilized opens the way to the resources of the asteroid belt and the outer planets; supports the creation of smart machines for space exploration and exploitation; and encourages the creation of autonomous niches of intelligent life within heliocentric space. All of these developments, in turn, establish the technological pathway for the first interstellar missions. Author

A89-20748
THE WAY TO MARS
V. GLUSHKO (AN SSSR, Moscow, USSR), L. GORSHKOV (AN SSSR, Sovet Interkosmos, Moscow, USSR), and Y. SEMENOV Planetary Report (ISSN 0736-3680), vol. 8, Nov.-Dec. 1988, p. 4-8.
Copyright

An article from the Soviet newspaper, Pravda, is presented, which discusses issues related to missions to Mars. The type of vehicle needed for a Martian mission is examined, including the propulsion system, construction of the vehicle in earth orbit, living quarters, safety considerations, and the landing vehicle. Options for the mission route and ways of returning to earth are considered. Also, a proposal for a three phase program leading up to a manned mission to Mars is outlined. R.B.

A90-12667
ENERGETIC IONS IN THE CLOSE ENVIRONMENT OF MARS AND PARTICLE SHADOWING BY THE PLANET
V. AFONIN, K. GRINGAUZ (AN SSSR, Institut Kosmicheskikh Issledovanii, Moscow, USSR), S. MCKENNA-LAWLOR (Saint Patrick's College, Maynooth, Republic of Ireland), K. KECSKEMETY (Magyar Tudomanyos Akademia, Kozponti Fizikai Kutato Intezet, Budapest, Hungary), E. KEPPLER (Max-Planck-Institut fuer Aeronomie, Katlenburg-Lindau, Federal Republic of Germany) et al. Nature (ISSN 0028-0836), vol. 341, Oct. 19, 1989, p. 616-618. Research supported by the Irish National Board for Science and Technology and BMFT. refs
Copyright

The twin-telescope particle-detector system, SLED, aboard Phobos 2 recorded flux enhancements in the range 30-350 keV in the same general location in the close environment of Mars, over eight days at about 900 km altitude in three successive elliptical orbits. Here, possible interpretations of these observations are presented. Energy-related particle shadowing by the body of Mars was also detected, and the data indicate that this effect occurred in less than 20 percent of the 114 circular orbits around Mars because of the nutation of the spacecraft. The influence of magnetic fields in allowing particles to reach the detector under potentially screened conditions is discussed. Author

A90-16662* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MARS ROVER SAMPLE RETURN MISSION STUDY
ROGER D. BOURKE (JPL, Pasadena, CA) IN: The case for Mars III: Strategies for exploration - General interest and overview. San Diego, CA, Univelt, Inc., 1989, p. 231-244.
(AAS PAPER 87-195) Copyright

The Mars Rover/Sample Return mission is examined as a precursor to a manned mission to Mars. The value of precursor missions is noted, using the Apollo lunar program as an example. The scientific objectives of the Mars Rover/Sample Return mission are listed and the basic mission plans are described. Consideration is given to the options for mission design, launch configurations, rover construction, and entry and lander design. Also, the potential for international cooperation on the Mars Rover/Sample Return mission is discussed. R.B.

A90-16663* National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
AN AERONOMY MISSION TO INVESTIGATE THE ENTRY AND ORBITER ENVIRONMENT OF MARS
LARRY H. BRACE (NASA, Goddard Space Flight Center, Greenbelt, MD) IN: The case for Mars III: Strategies for exploration - General interest and overview. San Diego, CA, Univelt, Inc., 1989, p. 245-257. refs
(AAS PAPER 87-196) Copyright

The need for an aeronomy mission to Mars as a precursor to a manned Mars mission is discussed. The upper atmosphere and radiation environment of Mars are reviewed, focusing on the implications of the Martian atmosphere for a manned mission. Plans for an aeronomy mission to Mars are described, including the Mars Aeronomy Observer and the Earth/Mars Aeronomy Orbiter. R.B.

A90-16665
SCIENTIFIC OBJECTIVES OF HUMAN EXPLORATION OF MARS
MICHAEL H. CARR (USGS, Menlo Park, CA) IN: The case for Mars III: Strategies for exploration - General interest and overview. San Diego, CA, Univelt, Inc., 1989, p. 267-275. refs
(AAS PAPER 87-198) Copyright

The scientific problems that could be addressed by human exploration of Mars are examined. Consideration is given to the origin and evolution of solid planets, the evolution of the atmosphere, and biological objectives such as searching for evidence of indigenous life. The methods that could be used to study these problems are discussed. R.B.

A90-16666* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
THE ROLE OF CLIMATE STUDIES IN THE FUTURE EXPLORATION OF MARS
RICHARD W. ZUREK and DANIEL J. MCCLEASE (JPL, Pasadena, CA) IN: The case for Mars III: Strategies for exploration - General interest and overview. San Diego, CA, Univelt, Inc., 1989, p. 277-285.
(AAS PAPER 87-199) Copyright

Three major reasons for the continued study of the weather and climate of Mars are: (1) the engineering support of future unmanned and manned missions, including operations on the Martian surface, (2) the comparative study of the climates of earth and Mars, and (3) the perspective provided by understanding what Mars is really like now and how it got that way. Together, the suite of national and international missions to Mars currently in progress and in the advanced planning stages could provide a credible data base for addressing many outstanding climatic questions, as well as greatly improving current engineering models of the Mars atmosphere and surface. Author

A90-16680* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
MARS SOIL - A STERILE REGOLITH OR A MEDIUM FOR PLANT GROWTH?
AMOS BANIN (NASA, Ames Research Center, Moffett Field; San Francisco State University, CA; Jerusalem, Hebrew University, Rehovot, Israel) IN: The case for Mars III: Strategies for exploration - General interest and overview. San Diego, CA, Univelt, Inc., 1989, p. 559-571. Research supported by the Hebrew University of Jerusalem. refs
(AAS PAPER 87-215) Copyright

The mineralogical composition and the physical, chemical and mechanical properties of the Mars soil have been the subject of a number of studies. Though definitive mineralogical measurements are lacking, elemental-chemical analyses and simulation experiments have indicated that clays are major components of the soil and that iron is present as adsorbed ion and as amorphous mineral coating the clay particles (Banin, 1986). Whether this soil can support plant growth or food production, utilizing conventional or advanced cultivational technologies, is a question that has not been thoroughly analyzed, but may be of importance and usefulness for the future exploration of Mars. Assuming that the proposed model of Mars soil components is valid, and drawing additional information from the analyses of the SNC meteorites believed to be ejected Mars rocks - the present contribution analyzes and evaluates the suitability of the soil as a medium for plant growth, attempting to identify the most critical limiting factors for such an undertaking and the possible remedies. Author

A90-47527* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
A GOAL AND STRATEGY FOR HUMAN EXPLORATION OF THE MOON AND MARS
DONNA SHIRLEY PIVIROTTO (JPL, Pasadena, CA) Space Policy

(ISSN 0265-9646), vol. 6, Aug. 1990, p. 195-208. refs
Copyright

Eventual settlement of the solar system, beginning with the moon and Mars, is proposed, and a strategy for the exploration of and initial settlement of the moon and Mars, based on the model of European settlement of the Americas, is discussed. Strategies suggest an allocation of functions between humans and telerobots to conduct the exploration and initial settlement. L.K.S.

A90-48738
OF MARTIAN ATMOSPHERES, OCEANS, AND FOSSILS
H. L. HELFER (C.E. Kenneth Mees Observatory, Rochester, NY) Icarus (ISSN 0019-1035), vol. 87, Sept. 1990, p. 228-235. refs
Copyright

A scenario is presently developed in which a substantial resemblance between Martian conditions up to 1.5 Gyr ago and those of the ancient earth led to the development of rudimentary life in Mars, in stages and on timescales that may be broadly comparable to terrestrial ones. The warm Martian oceans would give rise to both aerobic and anaerobic photosynthesizing prokaryotes, as well as such structures as stromatolites, which could in due course have transformed the Martian atmosphere as profoundly as those on earth. It is anticipated that the fossil remains of these rudimentary organisms can be found along the fringes of the ancient Martian oceans, which currently take the form of northern lowland plains. O.C.

A90-48751
INTERNATIONAL CONFERENCE ON MARS, 4TH, TUCSON, AZ, JAN. 10-13, 1989, PROCEEDINGS
BRUCE M. JAKOSKY, ED. (Colorado, University, Boulder) Conference sponsored by the American Geophysical Union and Geological Society of America. Journal of Geophysical Research (ISSN 0148-0227), vol. 95, Aug. 30, 1990, 766 p. For individual items see A90-48752 to A90-48804.
Copyright

Topics discussed included early history and solid-body geophysics; bedrock geology; surficial geology and surface-atmosphere interactions; climate, atmosphere, and volatile system; and the upper atmosphere, magnetosphere, and solar-wind interactions. Papers were presented on thermal history of Mars and the sulfur content of its core; the rigid body obliquity history of Mars; constraints on early events in Martian history as derived from the cratering record; the nature of the mantling deposit in the heavily cratered terrain of northeastern Arabia, Mars; and the flank tectonics of Martian volcanoes. Attention is also given to the origins of Marslike spectral and magnetic properties of a Hawaiian palagonitic soil, an assessment of the meteoritic contribution to the Martian soil, observations of Martian surface winds at the Viking Lander 1 site, variations of Mars gravitational field and rotation due to seasonal CO2 exchange, and plasma observations of the solar wind interaction with Mars. I.S.

A90-48783* Hawaii Univ., Honolulu.
POSSIBLE MARTIAN BRINES - RADAR OBSERVATIONS AND MODELS
AARON P. ZENT, FRASER P. FANALE (Hawaii, University, Honolulu), and LADISLAV E. ROTH (JPL, Pasadena, CA) Journal of Geophysical Research (ISSN 0148-0227), vol. 95, Aug. 30, 1990, p. 14531-14542. refs
(Contract NGT-50104; NAGW-538)
Copyright

The 1971 and 1973 Goldstone 12.6-cm radar observations of Mars are separate data sets which include reflectivity as a function of latitude, longitude, and season. It has been argued that secular reflectivity variations of Mars' surface are indicated by the data and that shallow subsurface melting is the causal mechanism most compatible with the observations; however, the melting hypothesis conflicts with accepted notions of the state and distribution of water on Mars. The data are examined to identify temporal and spatial domains within which statistically significant changes in measured reflectivity are clustered. Brines which might satisfy the best supported reflectivity variations are out of equilibrium with the chemical megaenvironment. It is unclear whether such a brine, if emplaced in the Martian regolith at a depth shallow enough to affect the radar reflectivity, could survive even a single freeze-thaw cycle. Some combination of unique scattering properties or some as yet unidentified process other than melting is responsible for any genuine reflectivity variations. Author

A90-48785* Washington Univ., Seattle.
OBSERVATIONS OF MARTIAN SURFACE WINDS AT THE VIKING LANDER 1 SITE
JAMES R. MURPHY, CONWAY B. LEOVY, and JAMES E. TILLMAN (Washington, University, Seattle) Journal of Geophysical Research (ISSN 0148-0227), vol. 95, Aug. 30, 1990, p. 14555-14576. refs
(Contract NSG-7085; NAGW-1341; NAG9-243)
Copyright

Martian surface winds at the Viking Lander 1 have been reconstructed using signals from partially failed wind instrumentation. Winds during early summer were controlled by regional topography, and then underwent a transition to a regime controlled by the Hadley circulation. Diurnal wind oscillations were controlled primarily by regional topography and boundary layer forcing, although a global mode may have been influencing them during two brief episodes. Semidiurnal wind oscillations were controlled by the westward-propagating semidiurnal tide from sol 210 onward. Comparison of the synoptic variations at the two sites suggests that the same eastward propagating wave trains were present at both sites. C.D.

A90-48789* Washington Univ., Seattle.
NUMERICAL SIMULATIONS OF THE DECAY OF MARTIAN GLOBAL DUST STORMS
JAMES R. MURPHY (Washington, University, Seattle), OWEN B. TOON, ROBERT M. HABERLE, and JAMES B. POLLACK (NASA, Ames Research Center, Moffett Field, CA) Journal of Geophysical Research (ISSN 0148-0227), vol. 95, Aug. 30, 1990, p. 14629-14648. refs
(Contract NGT-50231)
Copyright

The decay of Martian global (great) dust storms is investigated. One-dimensional (vertical, static atmosphere) and two-dimensional (latitude-height, steady state circulation) simulations carried out with an aerosol transport-microphysical model indicate that atmospheric motions play a significant role in the observed decay of global dust storms. Spacecraft observations (Mariner 9, Viking) of the 1971 and the two 1977 planet-encircling dust storms have provided suggestions about some characteristics of storm decay. Specifically, the dust particle size distribution is inferred to have remained essentially unchanged for particles with radii between 1 and 10 microns during decay of the 1971 storm, and surface visible opacity declined quasi-exponentially with time in northern midlatitudes during the decay of the two 1977 storms. The results from this investigation indicate that two- and three-dimensional dynamical processes play a significant role the observed decay features of Martian global dust storms. The most important processes are the lofting of dust by vertical motions in the dust source region of the Southern Hemisphere subtropics and a continuing advective resupply of atmospheric dust into the dust sink regions of the Northern Hemisphere. This work has implications for Viking data analyses and future Mars observer observations and requires that the particle size distribution be treated as a time and latitude dependent quantity. Author

A90-48791
METEOROLOGICAL SURVEY OF MARS, 1969 - 1984
JEFFREY D. BEISH (U.S. Naval Observatory, Miami, FL) and DONALD C. PARKER (Association of Lunar and Planetary Observers; Institute for Planetary Research Observatories, Miami, FL) Journal of Geophysical Research (ISSN 0148-0227), vol. 95, Aug. 30, 1990, p. 14657-14675. Research supported by the Institute for Planetary Research Observatories. refs
Copyright

Results of a survey of Martian blue, blue-white, white, and dust clouds contained in the observational archives of the Association of Lunar and Planetary Observers and in the personal files of the late C.F. Capen, Jr. are presented. A statistical analysis of data extracted from the records of 9650 visual and photographic observations of Mars made from 1969 through 1984 has been performed. Seasonal frequencies and trend analyses for each type of observed Martian meteorology are presented. Author

A90-48792* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ICE HAZE, SNOW, AND THE MARS WATER CYCLE
RALPH KAHN (JPL, Pasadena, CA) Journal of Geophysical Research (ISSN 0148-0227), vol. 95, Aug. 30, 1990, p. 14677-14693. refs
(Contract NAGW-660)
Copyright

Light curves and extinction profiles derived from Martian limb observations are used to constrain the atmospheric temperature structure in regions of the atmosphere with thin haze and to analyze the haze particle properties and atmospheric eddy mixing. Temperature between 170 and 190 K are obtained for three cases at levels in the atmosphere ranging from 20 to 50 km. Eddy diffusion coefficients around 100,000 sq cm/s, typical of a nonconvecting atmosphere, are derived in the haze regions at times when the atmosphere is relatively clear of dust. This parameter apparently changes by more than three orders of magnitude with season and local conditions. The derived particle size parameter varies systematically by more than an order of magnitude with condensation level, in such a way that the characteristic fall time is always about one Martian day. Ice hazes provide a mechanism for scavenging water vapor in the thin Mars atmosphere and may play a key role in the seasonal cycle of water on Mars. C.D.

A90-48797*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
VARIATIONS OF MARS GRAVITATIONAL FIELD AND ROTATION DUE TO SEASONAL CO2 EXCHANGE
B. FONG CHAO and DAVID PARRY RUBINCAM (NASA, Goddard Space Flight Center, Greenbelt, MD) Journal of Geophysical Research (ISSN 0148-0227), vol. 95, Aug. 30, 1990, p. 14755-14760. refs

About a quarter of the Martian atmospheric mass is exchanged between the atmosphere and the polar caps in the course of a Martian year: CO2 condenses to form (or add to) the polar caps in winter and sublimes into the atmosphere in summer. This paper studies the effect of this CO2 mass redistribution on Martian rotation and gravitational field. Two mechanisms are examined: (1) the waxing and waning of solid CO2 in the polar caps and (2) the geographical distribution of gaseous CO2 in the atmosphere. In particular, the net peak-to-peak changes in J2 and J3 over a Martian year are both found to be as much as about 6 x 10 to the -9th. A simulation suggests that these changes may be detected by the upcoming Mars Observer under favorable but realistic conditions. Author

A90-48798* Michigan Univ., Ann Arbor.
A NUMERICAL SIMULATION OF CLIMATE CHANGES DURING THE OBLIQUITY CYCLE ON MARS
L. M. FRANCOIS, J. C. G. WALKER, and W. R. KUHN (Michigan, University, Ann Arbor) Journal of Geophysical Research (ISSN 0148-0227), vol. 95, Aug. 30, 1990, p. 14761-14778. refs
(Contract NAGW-176)
Copyright

A one-dimensional seasonal energy balance climate model of the Martian surface is developed. The model shows the importance of using short-period diurnal and seasonal variations of solar irradiance instead of yearly-averaged quantities. The roles of meridional heat transport and greenhouse warming are shown to be important. The possible existence of hysteresis cycles in the formation and sublimation of permanent deposits during the course of the obliquity cycle is demonstrated. C.D.

A91-10160*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
GEOLOGIC EXPLORATION OF MARS
J. B. PLESCIA (JPL, Pasadena, CA) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 10 p.
(AIAA PAPER 90-3802) Copyright

The scientific objectives and methods involved in a geologic exploration of Mars from a manned outpost are discussed. The constraints on outpost activities imposed by the limited crew size, limited amount of time available for science, the limited diversity of scientific expertise, and the competition between scientific disciplines are addressed. Three examples of possible outpost locations are examined: the Olympus Mons aureole, Mangala Valles/Daedalia Planum, and Candor Chasma. The geologic work that could be done at each site is pointed out. C.D.

A91-10161*# Colorado Univ., Boulder.
WATER ON MARS - VOLATILE HISTORY AND RESOURCE AVAILABILITY
BRUCE M. JAKOSKY (Colorado, University, Boulder) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 9 p. refs
(Contract NAGW-552)
(AIAA PAPER 90-3803) Copyright

An attempt is made to define the available deposits of water in the near-surface region of Mars which will be available to human exploration missions. The Martian seasonal water cycle is reviewed, and geochemical and geological constraints on the availability of water are examined. It is concluded that the only sure source of water in amounts significant as a resource are in the polar ice deposits. C.D.

A91-10162*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MARTIAN WEATHER AND CLIMATE IN THE 21ST CENTURY
RICHARD W. ZUREK (JPL, Pasadena, CA) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 9 p. refs
(AIAA PAPER 90-3804) Copyright

The historical interest in the weather and climate of Mars and current understanding of aspects of the present climate are addressed. Scientific research into the weather and climate of Mars in the next century is examined. The impact of the Martian weather of the 21st century on humans that may then be inhabiting the planet is considered. C.D.

A91-19130#
DONATELLO - A PROPOSED MARS EXPLORATION INITIATIVE FOR THE YEAR 2050
JOHN G. VANDEGRIFT and BRIAN H. KENDALL (Texas A & M University, College Station) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 12 p. refs
(AIAA PAPER 91-0089) Copyright

This paper presents a conceptual design for a futuristic superfreighter which will transport large numbers of people and supplies to Mars for the construction of a large-scale scientific and manufacturing complex. Code named Project Donatello, the freighter will be assembled at the first libration point (L1) of the earth-moon system from materials supplied by heavy-lift launch vehicles from earth and from OTVs from the large-scale lunar base. Donatello will utilize an antimatter propulsion system to reduce Mars trip time and fuel mass requirements. On arrival at Mars, two smaller transfer ships will carry boxcar-sized payload canisters into the Martian atmosphere and to the vicinity of the existing Mars outpost. The vehicles will also have VTOL capabilities when transporting fuselage canisters containing the Mars base personnel. Author

A91-23308
SOME UNCONVENTIONAL APPROACHES TO THE EXPLORATION OF MARS

J. R. FRENCH Spaceflight (ISSN 0038-6340), vol. 33, Feb. 1991, p. 62-66. refs
Copyright

The topics of space transport to Mars, and surface transport and surface operations on Mars are discussed in detail and new options for accomplishing these activities are presented. The question of maximizing the return on the investment in a Mars mission is addressed. One way to accomplish this is through reduction of propellant requirements by increasing the performance of the rocket engine, while another option is to make use of nuclear fuel. A technique discussed in detail would provide a means to manufacture fuel from Martian resources for both the return trip and for Mars surface exploration. Options for Mars surface transport include battery and nuclear powered rovers, solar powered automobiles, and either battery, nuclear or Mars-generated-propellant-powered aircraft specially designed to explore the Martian surface. The advantages and disadvantages of each of these options are considered, and the usefulness of a manned aircraft for both exploration and surface operational functions is discussed. L.K.S.

A91-27649* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
IONIZING PROGRAM ENVIRONMENT AT THE MARS SURFACE
LISA C. SIMONSEN, JOHN E. NEALY, LAWRENCE W. TOWNSEND, and JOHN W. WILSON (NASA, Langley Research Center, Hampton, VA) IN: Engineering, construction, and operations in space II; Proceedings of Space 90, the Second International Conference, Albuquerque, NM, Apr. 22-26, 1990. Vol. 1. New York, American Society of Civil Engineers, 1990, p. 748-758. refs
Copyright

The Langley cosmic ray transport code and the Langley nucleon transport code are used to quantify the transport and attenuation of galactic cosmic rays and solar proton flares through the Martian atmosphere. Surface doses are estimated using both a low-density and a high-density carbon dioxide model of the atmosphere which, in the vertical direction, provide a total of 16 g/sq cm and 22 g/sq cm of protection, respectively. At the Mars surface during the solar minimum cycle, a blood-forming organ (BFO) dose-equivalent of 10.5 to 12 rem/yr due to galactic cosmic ray transport and attenuation is calculated. Estimates of the BFO dose-equivalents which would have been incurred at the surface from three large solar flare events are also calculated. Doses are also estimated at altitudes up to 12 km above the Martian surface where the atmosphere will provide less total protection. Author

A91-29587 California Inst. of Tech., Pasadena.
PRELIMINARY ASSESSMENT OF TERMOSKAN OBSERVATIONS OF MARS
B. MURRAY, B. H. BETTS, T. SVITEK (California Institute of Technology, Pasadena), M. K. NARAEVA, A. S. SELIVANOV (Institute for Space Devices, Moscow, USSR), D. CRISP, T. Z. MARTIN (JPL, Pasadena, CA) et al. (Colloquium on Phobos-Mars Mission, Paris, France, Oct. 23-27, 1989, Proceedings. A91-29558 11-91) Planetary and Space Science (ISSN 0032-0633), vol. 39, Jan.-Feb. 1991, p. 237-265. refs
(Contract NAGW-1426)
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The limited set of high-resolution observations of the 8-12 micron thermal emission from Mars' equatorial regions by the Termoskan instrument onboard the Phobos '88 spacecraft in February and March of 1989 is considered. Observations were also simultaneously acquired in the 0.5 to 1.0 micron region. A combined U.S. and Soviet scientific team made a preliminary quantitative evaluation of about 25 percent of the entire data set. It is found that there is a close agreement with the Viking Infrared Thermal Mapper brightness temperatures, confirming the accuracy of the Termoskan system and calibration. A novel pattern of emission from particles was observed in the morning and assumed to be water or ice. Thermal emission from surface features is varied and distinct down to the limit of resolution. The presence of unusually insulating material has been detected in the uppermost fraction of a millimeter of the Martian surface in places where the shadow of Phobos briefly eclipsed by the surface. L.K.S.

N90-15028*# Texas Univ., Austin. Dept. of Aerospace Engineering and Engineering Mechanics.
M.I.N.G., MARS INVESTMENT FOR A NEW GENERATION: ROBOTIC CONSTRUCTION OF A PERMANENTLY MANNED MARS BASE Final Report
JEFF AMOS, RANDY BEEMAN, SUSAN BROWN, JOHN CALHOUN, JOHN HILL, LARK HOWORTH, CLAY MCFADEN, PAUL NGUYEN, PHILIP REID, STUART REXRODE et al. 1 May 1989 124 p
(Contract NASW-4435)
(NASA-CR-186224; NAS 1.26:186224) Avail: NTIS HC A06/MF A01 CSCL 03B

A basic procedure for robotically constructing a manned Mars base is outlined. The research procedure was divided into three areas: environment, robotics, and habitat. The base as designed will consist of these components: two power plants, communication facilities, a habitat complex, and a hanger, a garage, recreation and manufacturing facilities. The power plants will be self-contained nuclear fission reactors placed approx. 1 km from the base for safety considerations. The base communication system will use a combination of orbiting satellites and surface relay stations. This system is necessary for robotic contact with Phobos and any future communication requirements. The habitat complex will consist of six self-contained modules: core, biosphere, science, living quarters, galley/storage, and a sick bay which will be brought from Phobos. The complex will be set into an excavated hole and covered with approximately 0.5 m of sandbags to provide radiation protection for the astronauts. The recreation, hangar, garage, and manufacturing facilities will each be transformed from the four one-way landers. The complete complex will be built by autonomous, artificially intelligent robots. Robots incorporated into the design are as follows: Large Modular Construction Robots with detachable arms capable of large scale construction activities; Small Maneuverable Robotic Servicers capable of performing delicate tasks normally requiring a suited astronaut; and a trailer vehicle with modular type attachments to complete specific tasks; and finally, Mobile Autonomous Rechargeable Transporters capable of transferring air and water from the manufacturing facility to the habitat complex. Author

N90-21709# Lawrence Livermore National Lab., CA. Special Studies Program.
MARS IN THIS CENTURY: THE OLYMPIA PROJECT
RODERICK A. HYDE, MURIEL Y. ISHIKAWA, and LOWELL L. WOOD 1988 17 p Presented at the 4th National Space Symposium, Colorado Springs, CO, 12-15 Apr. 1988
(Contract W-7405-ENG-48)
(DE90-008356; UCRL-98567; CONF-8804105-2) Avail: NTIS HC A03/MF A01

Manned exploration of the inner solar system, typified by a manned expedition of Mars, this side of the indefinite future involves fitting a technical peg into the political hole. If Apollo-level resources are assumed unavailable for such exploratory programs, then non-Apollo means and methods must be employed, involving greater technical and human risks, or else such exploration must be deferred indefinitely. Sketched here is an example of such a relatively high risk alternative, one which could land men on Mars in the next decade, and return them to earth. Two of its key features are a teleoperated rocket fuel generating facility on the lunar surface and an interplanetary mission staging space station at L(sub 4), which would serve to enable a continuing solar system exploratory program, with annual mission commencements to points as distant as the Jovian moons. The estimated cost to execute this infrastructure building manned Mars mission is $3 billion, with follow on missions estimated to cost no more than $1 billion each. DOE

N91-20015*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

CHEMICAL APPROACHES TO CARBON DIOXIDE UTILIZATION FOR MANNED MARS MISSIONS

ALOYSIUS F. HEPP, GEOFFREY A. LANDIS, and CLIFFORD P. KUBIAK (Purdue Univ., West Lafayette, IN.) 1991 22 p Presented at the 2nd Annual Symposium of the UA/NASA Space Engineering Research Center, Tucson, AZ, 7-10 Jan. 1991

(Contract NAS3-25266)
(NASA-TM-103728; E-5962; NAS 1.15:103728) Avail: NTIS HC/MF A03 CSCL 03B

Use of resources available in situ is a critical enabling technology for a permanent human presence in space. A permanent presence on Mars, e.g., requires a large infrastructure to sustain life under hostile conditions. As a resource on Mars, atmospheric CO2 is as follows: abundant; available at all points on the surface; of known presence; chemically simple; and can be obtained by simple compression. Many studies focus on obtaining O2 and the various uses for O2 including life support and fuel; discussion of CO, the coproduct from CO2 fixation revolves around its uses as a fuel, being oxidized back to CO2. Several new proposals are studied for CO2 fixation through chemical, photochemical, and photoelectrochemical means. For example, the reduction of CO2 to hydrocarbons such as acetylene (C2H2) can be accomplished with H2. C2H2 has a theoretical vacuum specific impulse of approx. 375 secs. Potential uses were also studied of CO2, as obtained or further reduced to carbon, as a reducing agent in metal oxide processing to form metals or metal carbides for use as structural or power materials; the CO2 can be recycled to generate O2 and CO. Author

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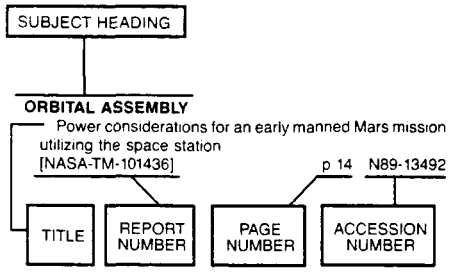

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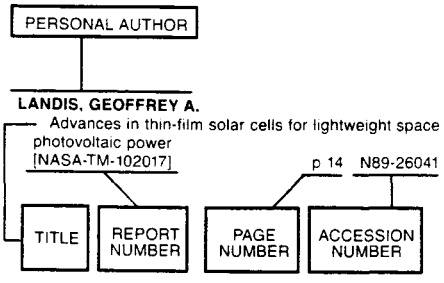

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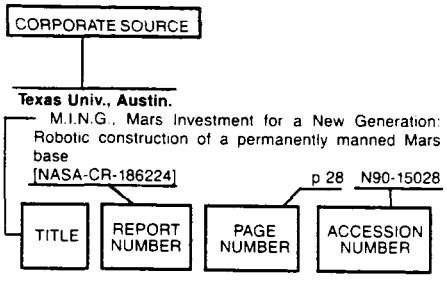

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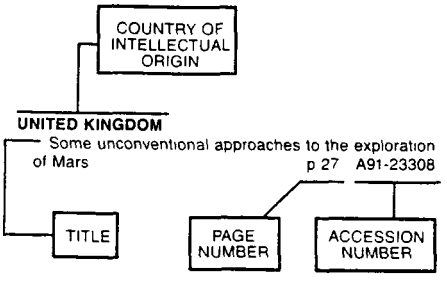

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The moon/Mars adventure - Which role and which impacts for Europe?
[IAF PAPER 90-411] p 6 A91-14015

G

GERMANY,FEDERAL REPUBLIC OF
Common approach for planetary habitation systems implementation
[MBB-UO-0115-90-PUB] p 21 N91-16570

N

NORWAY
Providing a sound habitat for man in space
p 20 A91-23463

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U.S.S.R.
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Emerging views on a joint Soviet-U.S. Mars mission
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Regenerative life-support system development problems for the Mars mission p 20 A91-23462
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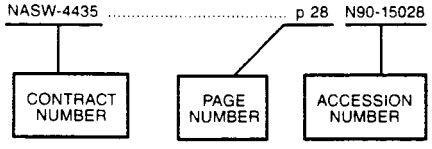

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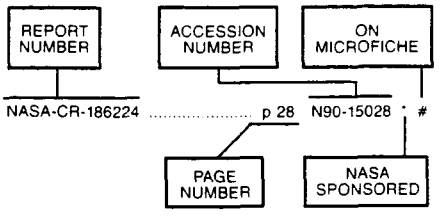

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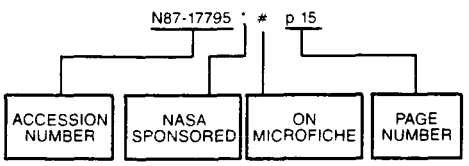

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15. *Supplementary Notes*

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